

**ADSORPTIVE REMOVAL OF TEXTILE DYES (CIBACRON YELLOW C5G)  
FROM AQUEOUS SOLUTION BY COCONUT COIR CARBON**

by

Aizat B Muhamad Jani

Submitted in partial fulfillment of  
the requirements for the  
Bachelor of Engineering (Hons)  
(Civil Engineering)

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**CERTIFICATION OF APPROVAL**


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Approved by,

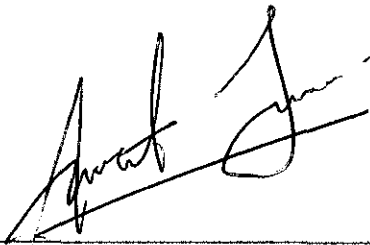
  
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(PROF. DR MALAY CHAUDHURI)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

## CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the reference and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



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AIZAT B MUHAMAD JANI

## **ABSTRACT**

This report consists of four important chapters that cover the introduction, problems statement, objectives of the projects, review of related literature, project methodology and the conclusions. The introduction part briefly discusses the background of the textile dyes. For the second part, the focus is more on the problem statement that covers problem identification and the significant of the projects. Part three is where the objectives of the project are stated and it describes more on the relevance and the feasibility of the project within the scope and time frame given. The review of related literature on textile dyes and coconut coir is enclosed in part four while the project methodology is covered in part five of the report. The project conclusion is also stated in the report together with the references used while doing research works on this project.

The objective of this project is to investigate the effectiveness of coconut coir carbon in adsorptive removal of textile dyes from aqueous solution. It is found to be maximum removal of 82.55 and 73.3 % in 0.1 g coconut coir activated carbon for 5 hours contact time in 2 mg/L and 5 mg/L of CYC5G concentration respectively. From the adsorption study, maximum adsorption capacity of 4.028 and 9.278 mg/g of coconut coir activated carbon were observed at an adsorbent dose of 0.4 g/L in 2 mg/L and 5 mg/L of CYC5G concentration respectively. From the column studies, it has shown that the adsorption is greater at the slow rate of flow and in thicker bed depth.

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# CHAPTER 1

## INTRODUCTION

### **1.1** Background

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The first synthetic dye, mauvein, was discovered at the middle of 18<sup>th</sup> century contributed to the generation of more than 100,000 new synthetic dyes. These dyes are used in different industries, including textiles, paper, pharmaceutical and food. The textile industry accounts for two-thirds of total dyestuff market and these dyes cannot be easily degraded while some are toxic to animals and human-being. During the dyeing process, approximately 10-15% of the used dye is discharge of which cause serious environmental and health hazards. Presence of the dyes in aqueous ecosystems diminishes the photosynthesis by impeding the light penetration into deeper layers thereby deteriorating the water quality and lowering the gas solubility. A number of methods can be used to treat the wastewater and one of them is adsorption by activated carbon. The activated carbon can be prepared from carbonaceous such as coal, lignite, wood, husk and coir, etc. Coconut coir is widely available in abundant quantities in Malaysia, especially from the food processing industry.

## 1.2 Problem Statement

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Treatment of textile dyes wastewater by chemical or physico-chemical methods, complete destruction of dye molecules by electrolysis or ozonation are in general costly and of limited applicability. Furthermore, it may produce large amounts of toxic waste which is difficult to dispose. The conventional treatment process usually cannot efficiently decolorize the effluents contaminated with textile dyes. From few studies made, activated carbon is one adsorbent, which has shown good adsorption capacity and considered effective in decolourization and water treatment. However, this process could lead to high cost in operation (Elliot *et al.* 1989).

The problem emerges when textile industry especially for small industry are less concerned about their environmental responsibility. The waste water that contains excess dye is often released directly into the drainage system without being treated first. Then, the waste water from the drainage enters and pollutes the rivers. This severe issue should not be held back only by these small scale operators because they surely cannot afford or consider to have expensive treatment plants or in other words, they cannot risk themselves and their business to handle hazardous chemical agent.

The available techniques to treat excess dye in water are by adding hazardous metal halide chemical agents and expensive air flotation method that requires huge tanks or ponds. The idea of having an air floatation tank is not really cost effective. The usage of chemical agents seems to be practical but in order to get this chemical agent, each operator has to go through a time wasting procedure and form-filling .

The excess dye in water can cause severe dermatitis, eye irritation, asthma, convulsions, and even coma to humans. This is because the dye wastewater may contains aluminum hydroxide and hydrogen peroxide that brings harmful effects to human. More than that, the number of small scale textile manufacturers is large and unregistered; law enforcers have problems to make sure all of them obey the procedure of waste water management.



Few studies show activated carbons prepared from organic waste materials contribute to the decolourization and reduction of colour (Singh, 2006) The usage of waste material in the treatment will give benefit in term of cost reduction compare to the conventional treatment process. In Malaysia, coconut coir is considered a waste or by-products and is abundant. Utilisation of the waste material will also contribute to reduce the landfill use for solid waste management.

### **1.3 Objectives and Scope of Study**

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The objective of this research project is to investigate the effectiveness of coconut coir activated carbon prepared from coconut coir to decolourize the textile dyes specifically Cibacron Yellow C5G from aqueous solution. Based of the objective, the possibility of using organic waste material to decolourize of textile dyes in wastewater is expected from this research.

The scope for the project covers a treatment method using coconut coir activated carbon prepared from coconut coir. The project requires experimental program that will be conducted in the environmental engineering laboratory. At first the aqueous solution of textile dyes will be prepared, followed by preparation of activated carbon from coconut coir, and observe the characteristics of water sample when react with the coconut coir activated carbon.

The data from the experimental program will be compared and analyzed and a conclusion to the study will be made based on the results obtained.

## CHAPTER 2

### LITERATURE REVIEW

#### **2.1** Textile dyes

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The textile industry is one of the big consumers of water. As a result of various processes, considerable amounts of wastewater are released. Representative magnitudes for water consumption are 100–200 L of water per kilogram of textile product. Considering an annual production of 40 million tons of textile fibers, the release of wastewater can be estimated to exceed 4–8 billion cubic meters per year. The production of textile requires several stages of mechanical processing such as spinning, weaving, knitting, and garment production, which seem to be insulated from the wet treatment processes like pretreatment, dyeing, printing, and finishing operations, but there is a strong interrelation between treatment processes in the dry state and consecutive wet treatments. For a long time the toxicity of released wastewater was mainly determined by the detection of biological effects from pollution, high bulks of foam, or intensively colored rivers near textile plants (Engber, 2005).

Time has changed and the identification and classification of wastewater currently are fixed by government regulations. General regulations define the most important substances to be observed critically by the applicant, and propose general strategies to be applied for minimization of the release of hazardous substances. The proposed set of actions has to be integrated into processes and production steps. Figure 1 gives a general overview of a textile plant and also indicates strategic positions for actions to minimize ecological impact. In this figure, the textile plant is defined as a structure that changes the properties of a textile raw material to obtain a desired product pattern (Bechtold *et al.* 2006)

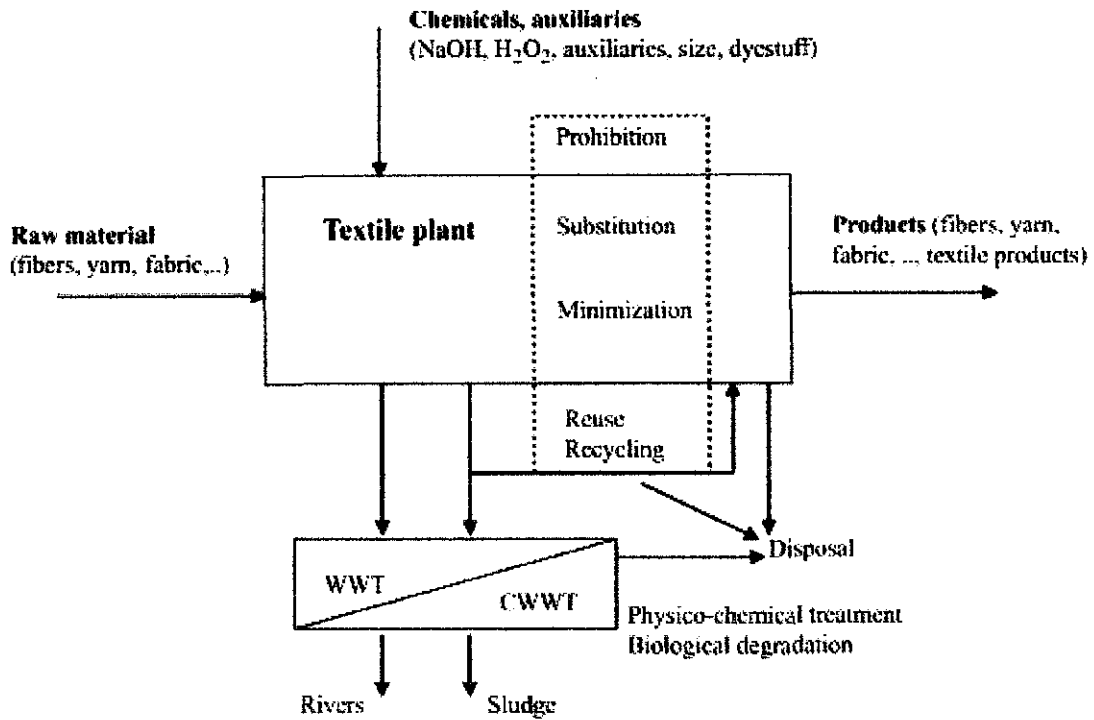


Figure 1 : Flow Structure of the a textile plant (Bechtold *et al.* 2006)

### **Definitions and Limits**

For a long time the treatment of textile effluents has concentrated mainly on two aspects which is regeneration of concentrated effluents with regard to savings of chemicals and lowering of chemical costs and treatment of effluents with high toxicity (Bechtold *et al.*, 2006).

Over the last decade the situation has changed and limits for a considerable number of compounds and parameters have been defined to avoid problems with regard to the following:

- Biototoxicity ( e.g., disturbance of biodegradation processes )
- Heavy metal content ( accumulation in sludge of wastewater treatment plant )
- Corrosion problems ( e.g., sulfate can cause corrosion of concrete tubes )
- Total COD/BOD load in the released effluents (capacity of the wastewater treatment plant )

Table1 gives an extract of important parameters for wastewater from textile plants as defined by the Austrian Government. The table contains limits defined for both direct release into surface water (rivers) and for release into wastewater treatment plant.

The activities to treat hazardous wastes can range from legal prohibition to cost saving recycling of chemicals. Depending on the type of product and treatment, these steps can show extreme variability. Normally the legal regulations are interpreted as a set of wastewater limits that have to be kept, but in fact the situation is more complex and at present a complex structure of actions has been defined and has described useful strategies to improve an actual situation (Engber, 2005).

Table 1 : Representative Limits Defined for Release of Textile Wastewater (Bechtold *et al.*, 2006)

Limits for emission	Release into river	Release into CWWT
<b>General parameters</b>		
Temperature (°C)	30	40
Toxicity	<2	No hindrance of biodegradation
Filter residue (mg/L)	30	500
Sediments (mL/L)	<0.3	---
pH	6.5-8.5	6.5-9.5
<b>Color, spectral coefficient of extinction:</b>		
436 nm (yellow) ( $m^{-1}$ )	7.0	28.0
525 nm (red) ( $m^{-1}$ )	5.0	24.0
620 nm (blue) ( $m^{-1}$ )	3.0	20.0
<b>Inorganic parameters (mg/L)</b>		
Aluminum	3	Limited by filter residue
Lead	0.5	0.5
Cadmium	0.1	0.1
Chromium total	0.5	1
Chromium-VI	0.1	0.1
Iron	2	Limited by filter residue
Cobalt	0.5	0.5
Copper	0.5	0.5
Zinc	2	2
Tin	1	1
Free chlorine (as $Cl_2$ )	0.2	0.5
Chlorine total (as $Cl_2$ )	0.4	1
Ammonium (as N)	5	---
Total phosphor (as P)	1	No problems in P elimination
Sulfate (as $SO_4$ )	---	200
<b>Organic parameters (mg/L)</b>		
TOC (total organic carbon as C)	50	>70% biodegradation
COD (chemical oxygen demand as $O_2$ )	150	>70% biodegradation
BOD <sub>5</sub> (biological oxygen demand as $O_2$ )	20	---
AOX (adsorbable organic halogen as Cl)	0.5	0.5
Total hydrocarbon	5	15
VOX (volatile organic halogen)	0.1	0.2
Phenol index calculated as phenol	0.1	10
Total anionic and nonionic surfactants	1	No problems in sewer and CWWT

Coir (Etymological origin: from Malayalam - *kayar* - cord) is a coarse fibre extracted from the fibrous outer shell of a coconut. Coir fibers are found between the husk and the outer shell of a coconut.

The individual fiber cells are narrow and hollow, with thick walls made of cellulose. They are pale when immature but later become hardened and yellowed as a layer of lignin is deposited on their walls. There are two varieties of coir. Brown coir is harvested from fully ripened coconuts. It is thick, strong and has high abrasion resistance. It is typically used in mats, brushes and sacking. Mature brown coir fibers contain more lignin and less cellulose than fibers such as flax and cotton and so are stronger but less flexible. They are made up of small threads, each about 1 mm long and 10 to 20 micrometres in diameter. White coir fibers are harvested from the coconuts before they are ripe. These fibers are white or light brown in color and are smoother and finer, but also weaker. They are generally spun to make yarn that is used in mats or rope.

Coir fibres make up about 1/3 of the of coconut pulp. The other 2/3 is called the pith or dust, it is biodegradable but takes 20 years to decompose. Once considered useless it is now being used as mulch, soil treatment and a hydroponic growth medium.

Activated carbon, also called activated charcoal or activated coal, is a general term which covers carbon material mostly derived from charcoal. For all three variations of the name, "activated" is sometimes substituted by "active". By any name, it is a material with an exceptionally high surface area. Just one gram of activated carbon has a surface area of approximately 500 m<sup>2</sup>, typically determined by nitrogen gas adsorption, and includes a large amount of microporosity. Sufficient activation for useful applications may come solely from the high surface area, though often further chemical treatment is used to enhance the absorbing properties of the material (Elliot *et al.*, 1989).

Municipal water treatment plants generally use activated carbon in two ways. It's by running the water through carbon filters or they pass it over a bed of carbon. Either way, no carbon remains in the water once it's been thoroughly treated. The efficiency of pollution to be treated by carbon depends on a number of factors, including the temperature and acidity of the water, the type and amount of pollution, and the amount of time the water spends in contact with the carbon (Engber, 2006)

A carbon with large holes would be best at picking up heavy organic chemicals, while smaller pores would catch the lighter pollutants. Different types of carbon can be activated in different ways or they can come from different source materials. Some are made from coal, wood, or sawdust, while others are made from peach pits, olive pits, or coconut shells. Manufacturers rate their products according to how much they can adsorb. The "molasses number," for example, tells you how well they adsorb the dark color from a mixture of water and molasses.

It can be produced in two different processes from a variety of carbonaceous source materials, e.g. nutshells, wood, coal, coconut husks, coconut coir (Elliot *et al.*, 1989). It can be produced using one of the two following processes:

1. Physical reactivation: The precursor is developed into activated carbons using gases. This is generally done by using one of or combining the following processes:
  - *Carbonization*: Material with carbon content is pyrolysed at temperatures in the range 600-900 °C, in absence of air (usually in inert atmosphere with gases like argon)
  - *Activation/Oxidation*: Raw material or carbonised material is exposed to oxidizing atmospheres (oxygen, or steam) at temperatures above 250 °C, usually in the temperature range 600-1200 °C.
2. Chemical activation: Impregnation with chemicals such as acids like phosphoric acid or bases like potassium hydroxide, sodium hydroxide or salts like zinc chloride, followed by carbonization at temperatures in the range 450-900 °C. It is believed that the carbonization / activation step proceeds simultaneously with the chemical activation. This technique can be problematic in some cases because, for example, zinc trace residues may remain in the end product. However, chemical activation is preferred over physical activation owing to the lower temperatures and shorter time needed for activating material.

Activated carbon is used in gas purification, metal extraction, water purification, medicine, sewage treatment, air filters in gas masks and filter masks, filters in compressed air and many other applications

Carbon adsorption has numerous applications in removing pollutants from air or water streams both in the field and in industrial processes such as:

- Spill cleanup
- Groundwater remediation
- Drinking water filtration
- Volatile organic compounds capture from painting, dry cleaning and other processes.



Adsorption is a process that occurs when a gas or liquid solute accumulates on the surface of a solid or, more rarely, a liquid (adsorbent), forming a molecular or atomic film (the adsorbate). It is different from absorption, in which a substance diffuses into a liquid or solid to form a solution. The term *sorption* encompasses both processes, while desorption is the reverse process (Cussler, 1997).

Adsorption is operative in most natural physical, biological, and chemical systems, and is widely used in industrial applications such as activated charcoal, synthetic resins and water purification. Adsorption, ion exchange and chromatography are sorption processes in which certain adsorptives are selectively transferred from the fluid phase to the surface of insoluble, rigid particles suspended in a vessel or packed in a column.

Similar to surface tension, adsorption is a consequence of surface energy. In a bulk material, all the bonding requirements (be they ionic, covalent or metallic) of the constituent atoms of the material are filled. But atoms on the (clean) surface experience a bond deficiency, because they are not wholly surrounded by other atoms. Thus it is energetically favourable for them to bond with whatever happens to be available. The exact nature of the bonding depends on the details of the species involved, but the adsorbed material is generally classified as exhibiting physisorption or chemisorption.

### Adsorbents

The adsorbents are used usually in the form of spherical pellets, rods, moldings or monoliths with hydrodynamic diameter between 0.5 and 10 mm. They must have high abrasion resistance, high thermal stability and small micropore diameter, which results in higher exposed surface area and hence high capacity of adsorption. The adsorbents must also have a distinct macropore structure which enables fast transport of the gaseous vapours.

Different types of industrial adsorbents generally fall into three classes:

- Oxygen-containing compounds – Are hydrophilic and polar, including materials such as silica gel and zeolites.
- Carbon-based compounds – Are hydrophobic and non-polar, including materials such as activated carbon.
- Polymer-based compounds - Are polar or non-polar functional groups in a porous polymer matrix.

The term absorption refers to the physical process of absorbing light, while absorbance refers to the mathematical quantity. Also, absorbance does not always measure absorption: if a given sample is, for example, a dispersion, part of the incident light will in fact be scattered by the dispersed particles, and not really absorbed. Absorbance only contemplates the ratio of transmitted light over incident light, not the mechanism by which light intensity decreases. Despite this fact, absorbance can still be used to determine concentrations (of particles) in such cases. Outside the field of analytical chemistry, the absorbance is sometimes defined as the natural logarithm instead of the base-10 logarithm. Although absorbance does not have true units, it is quite often reported in "Absorbance Units" or AU (Rabin *et al.*, 2002).

### **Instrument Measurement range**

Any real measuring instrument has a limited range over which it can accurately measure absorbance. An instrument must be calibrated and checked against known standards if the readings are to be trusted. Many instruments will become non-linear (fail to follow the Beer-Lambert law) starting at approximately 2 AU (~1% Transmission). It is also difficult to accurately measure very small absorbances that are very close to zero absorbance. The theoretical best accuracy for most instruments is in the range near 1 AU. When possible, the path length or concentration should be adjusted to achieve readings near this range. It is extremely difficult to achieve a large instrument range, between 0 and 6 AU. Optical density, or OD, is the absorbance per unit length, i.e., the absorbance divided by the thickness of the sample, although it is sometimes used as a synonym for the absorbance with a base-10 logarithm (Rabin *et al.*, 2002).

In spectroscopy, the absorbance  $A$  is defined as (Beer-Lambert Law) :

$$A_{\lambda} = \log_{10}(I/I_0),$$

where  $I$  is the intensity of light at a specified wavelength  $\lambda$  that has passed through a sample (transmitted light intensity) and  $I_0$  is the intensity of the light before it enters the sample or incident light intensity. Absorbance measurements are often carried out in analytical chemistry, since the absorbance of a sample is proportional to the thickness of the sample and the concentration of the absorbing species in the sample, in contrast to the transmittance  $I / I_0$  of a sample, which varies exponentially with thickness and concentration.

## CHAPTER 3

### METHODOLOGY

#### **3.1 Research**

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- Cover all the study through reading and understanding from literature review, case study, journal, fiction book, text book, website, articles and other reading materials. It is a self study to detail understand and to get as much as knowledge and information about the project.
- Prepare all the information and materials needed for laboratory works.

#### **3.2 Laboratory**

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##### **Preparation of Activated Carbon from Coconut Coir**

1. Coconut coir carbon was prepared according to a method used by Santhy & Selvapathy (2006) by crushing the coconut coir to a finer fraction before converting it into carbon.
2. Then it was treated by 100 g of coconut coir with 100 ml of concentrated sulphuric acid ( $H_2SO_4$ ) and will be kept into an oven at  $105^\circ C$  for 24 hours.
3. It had been washed with water to remove free acid and dried at  $105^\circ C$  for 24 hours.
4. The dried material was then subjected to thermal activation at  $800^\circ C$  for a period of 30 minutes in the absence of air (argon atmosphere).
5. Then it was sieved and particle with size range of 325-500  $\mu m$  used for the study

## **Dye Measurement**

1. Aqueous solutions for the four types of dyes were prepared and one type of textile dyes named Cibacron Yellow C5G was prepared in various concentrations.
2. The powdered form of Cibacron Yellow C5G was prepared into a 500 mg/L concentration.
3. The concentration then were diluted into 2 mg/L, 5 mg/L, 10 mg/L, 20 mg/L, 30 mg/L, 40 mg/L, 50 mg/L, 75 mg/L and 100 mg/L concentrations and kept into the volumetric flasks.
4. A 25 ml pipette was used to take the sample for the purpose of constant sample taken from the aqueous solution.
5. The samples were placed in different vials according to its concentration and the absorbance values were read at different wavelength.
6. A spectrophotometer was used to measure the wavelength of maximum absorbance.
7. Before placing the dye, a zero sample from distilled water was placed at spectrophotometer as reference for absorbance value of the dye
8. The wavelength of maximum absorbance Cibacron Yellow C5G was obtained.
9. After getting all the maximum absorbance value from all different concentrations for Cibacron Yellow C5G, standard curve was plotted by plotting absorbance of optimum wavelength against corresponding concentration of the dye.

## **Preparation for Dye Adsorption Study**

1. Experiment in batches had carried out by shaking 50 ml of dye solution with 0.1 g of the adsorbent in glass stoppered conical flask at a temperature of 20°C (room temperature) at the rate of 150 rpm by using orbital shaker.
2. Effect of various parameters such as initial concentration, contact time, pH and adsorbent dose on the adsorption process was investigated.
3. The progress of adsorption during the experiments was determined by removing flasks after desired contact time, centrifuging and analysis the supernatant spectrophotometrically for dye concentration
4. Column study was conducted by using a downflow technique
5. The granular carbon was packed into a column of 15 cm and 30 cm height with internal diameter of 1.5 cm
6. The breakthrough curve was obtained by investigating the effect of flow rate and bed depth.

### 3.3 Data Analysis

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- Analyzing and comparing of data obtained from the experiment. Some calculation will be required and few graphs will be plotted especially for spectrometer analysis

### 3.4 Safety and Hazard Analysis

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In this FYP II, the study is based on experiments that required the used chemicals in the laboratory. It is important to know the hazard of chemicals used in order to make sure the safety measurement is being prioritized. Chemicals commonly used :

#### 1) Sodium Bicarbonate

##### *Potential Health Effects*

**Inhalation:** High concentrations of dust may cause coughing and sneezing.

**Ingestion:** Extremely large oral doses may cause gastrointestinal disturbances.

**Skin Contact :** No adverse effects expected.

**Eye Contact:** Contact may cause mild irritation, redness, and pain.

**Chronic Exposure :** No information found.

**Aggravation of Pre-existing Conditions :** No information found.

##### *First Aid Measures*

**Inhalation :** Remove to fresh air. Get medical attention for any breathing difficulty.

**Ingestion:** Give several glasses of water to drink to dilute. If large amounts were swallowed, get medical advice.

**Skin Contact :** Not expected to require first aid measures.

**Eye Contact:** Wash thoroughly with running water. Get medical advice if irritation develops.



## 2) Sulfuric Acid

### *Potential Health Effects*

**Inhalation :** Corrosive. Burning sensation. Sore throat. Cough. Laboured breathing. Shortness of breath. Symptoms may be delayed

**Skin :** Corrosive. Redness. Pain. Blisters. Serious skin burns.

**Eyes :** Corrosive. Redness. Pain. Severe deep burns.

**Ingestion :** Corrosive. Abdominal pain. Burning sensation. Shock or collapse.

### *First Aid Measures*

**Inhalation :** Fresh air, rest. Half-upright position. Artificial respiration may be needed. Refer for medical attention.

**Skins :** Remove contaminated clothes. Rinse skin with plenty of water or shower. Refer for medical attention

**Eyes :** First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.

**Ingestion :** Rinse mouth. Do NOT induce vomiting. Refer for medical attention.

## 3) Cibacron Yellow C5G

### *Potential Health Effects*

**Swallowed :** slight (Oral,Rat LD50) >2000 mg/kg

**Eye :** Non-irritant

**Skin :** Non-irritant

**Inhaled :** Not yet available, but may cause respiratory

### ***First Aid Measures***

**Swallowed :** Wash mouth with water, drink plenty of water. Seek medical advice

**Eye :** Rinse immediately with cool and clean running water for at least 15 minutes

**Skin :** Clear contaminated areas with soap and plenty of running water. Remove contaminated clothing.

**Inhaled :** Remove patient to fresh air, rest. If symptoms of asthma or breathing difficulties occur, seek medical

#### **4) Hydrochloric Acid**

### ***Potential Health Effects***

**Inhalation :** Corrosive. Burning sensation. Cough. Laboured breathing. Shortness of breath. Sore throat. Symptoms may be delayed

**Skin :** ON CONTACT WITH LIQUID: FROSTBITE. Corrosive. Serious skin burns. Pain.

**Eyes :** Corrosive. Pain. Blurred vision. Severe deep burns.

### ***First Aid Measures***

**Inhalation :** Fresh air, rest. Half-upright position. Artificial respiration may be needed. Refer for medical attention.

**Skins :** First rinse with plenty of water, then remove contaminated clothes and rinse again. Refer for medical attention

**Eyes :** First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.

**CHAPTER 4**  
**RESULTS AND DISCUSSION**

**4.1 Results**

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From the methodology, some work had been done towards the completion of this project. Experimental materials, apparatus and laboratory instruments also had been prepared. Some of the completed work are :

1. Preparation of coconut coir into finer fraction and washing thoroughly with distilled water and dried it at 105°C for 24 hours in an oven
2. 100 g of dried coconut coir were with concentrated sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) and was kept in oven at at 105°C for 24 hours. In observation, the coconut coir turned to black colour when reacted with concentrated sulphuric acid.
3. For preparing activated carbon from coconut coir in a furnace at 800°C with absence of air (argon atmosphere).

## Dye Measurements ( Cibacron Yellow C5G)

Colored solutions are colored because they absorb certain wavelengths of light while allowing other wavelengths of light to pass through. As observers, we see the wavelengths of light that are not absorbed. By measuring the amount of light absorbed, we can find the concentration of solutions. Before doing this type of spectral analysis, the wavelength at which absorbance is greatest needs to be determined. The spectrophotometer is more sensitive to absorbance changes at this wavelength.

As the measurements was done using Cibacron Yellow C5G, a sample of the dye with concentration 500 mg/L was made and diluted into 2 mg/L, 5 mg/L, 10 mg/L, 20 mg/L, 30 mg/L, 40 mg/L, 50 mg/L, 75 mg/L and 100 mg/L concentration. These concentrations were placed in spectrophotomer (DR5000) at the wavelength of maximum absorbance (418 nm) to obtain the absorbance value for each concentration . The results are shown below :

Table 2 : Concentration Cibacron Yellow C5G with absorbance value

Concentration (mg/L)	Absorbance
0	0
2	0.149
5	0.322
10	0.503
20	1.038
30	1.563
40	2.031
50	2.525
60	2.950

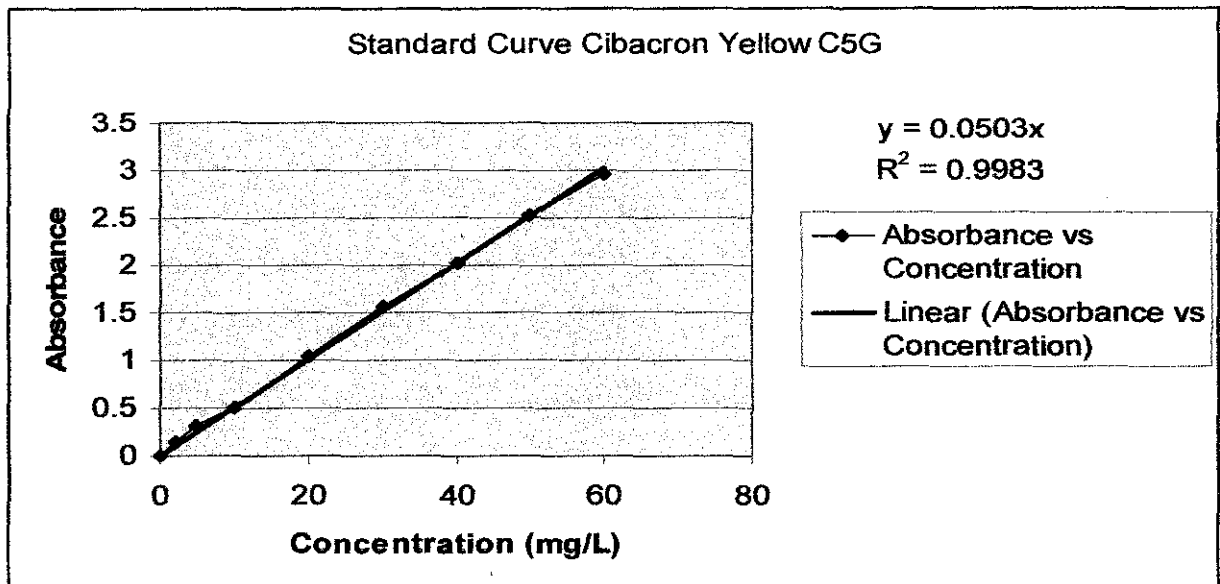


Figure 2 : Graph of Absorbance VS Concentration of Cibacron Yellow C5G

A standard curve was made from different concentrations of a single dye against absorbance at each concentration wavelength for maximum absorbance. The percentage of colour removal (decolourisation) will be calculated after knowing the dye concentration before and after experiment. From the standard curve, we may obtain the concentration of unknown sample from the maximum absorbance value of the sample.

#### **Effect of initial concentration and contact time**

The effect of initial dye concentration and contact time on the removal of Cibacron Yellow C5G (concentration of 5mg/L and 10mg/L) is shown in Table 3 and Figure 3. From the figure, it was evident that the removal of dye increased by with an increase in contact time. It was found that equilibrium was attained at 5 hour of contact time.

Table 3 : Effect of initial concentration and contact time on the adsorption of Cibacron Yellow C5G by coconut coir activated carbon

Contact time hour	2 mg/L CYC5G		5 mg/L CYC5G	
	Final concentration mg/L	Removal %	Final concentration mg/L	Removal %
0.5	1.611	19.45	4.208	15.84
1	1.369	31.55	3.602	27.96
2	1.074	46.3	3.214	35.72
3	0.738	63.1	2.376	52.48
4	0.537	73.15	1.801	63.98
5	0.362	81.9	1.351	72.98
6	0.349	82.55	1.335	73.3
7	0.349	82.55	1.335	73.3

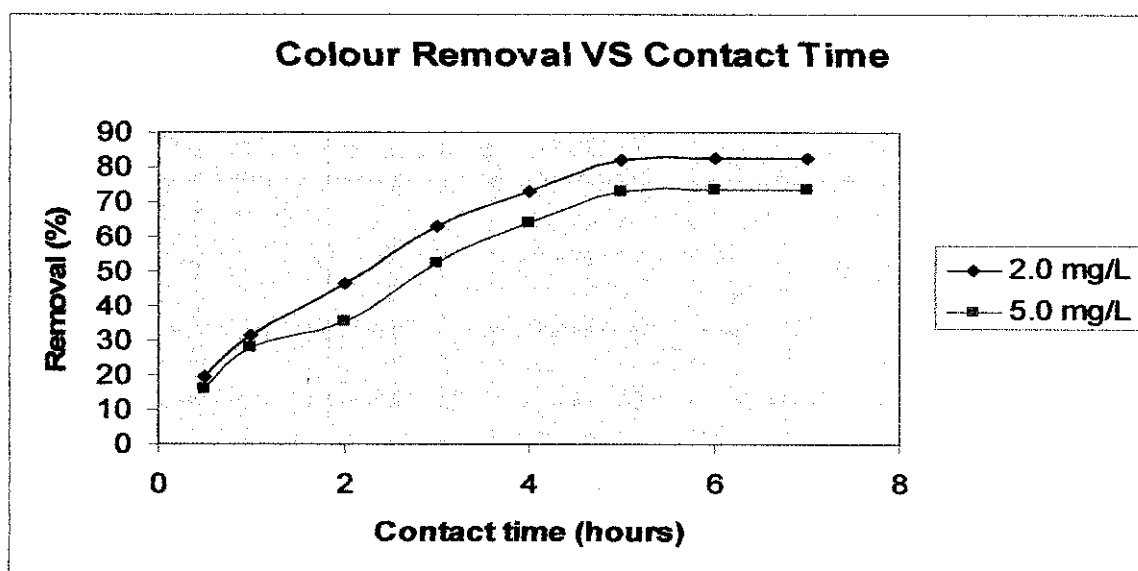


Figure 3 : Effect of initial concentration and contact time on the adsorption of Cibacron Yellow C5G by coconut coir activated carbon

### Effect of pH.

The removal of dyes as a function of pH is shown in Figure 4 . The removal of dyes by CPC was found to maximum in the acidic pH range of 1-2. The pH value of dye solution plays an important role in the whole adsorption process and particularly on the adsorption capacity. Similar observations have been reported by others for adsorption of reactive dyes indicating that the carbon has a net positive charge on its surface (Bousher

et al., 1997). As the pH of the adsorption solution was lowered, the positive charge on the surface increased. This would attract negatively charged functional groups located on the textile dyes. In subsequent studies, it was decided to maintain a pH of 2.0, at which removal was maximum.

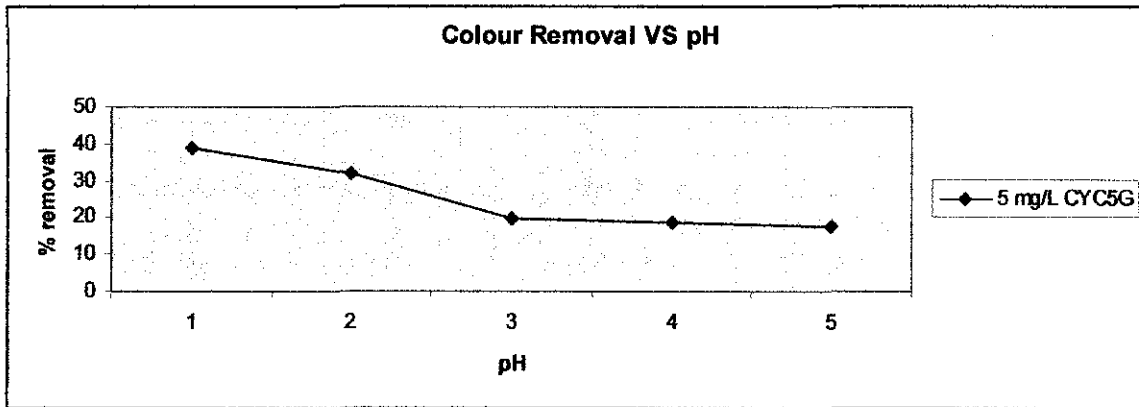


Figure 4 : Effect of pH on the adsorption of Cibacron Yellow C5G by activated carbon

#### Effect of carbon dose

The effect of carbon dose on removal of Cibacron Yellow C5G Dye is shown in Figure 5. It was observed that the dye uptake increased with increasing of adsorbent dosage of carbon.

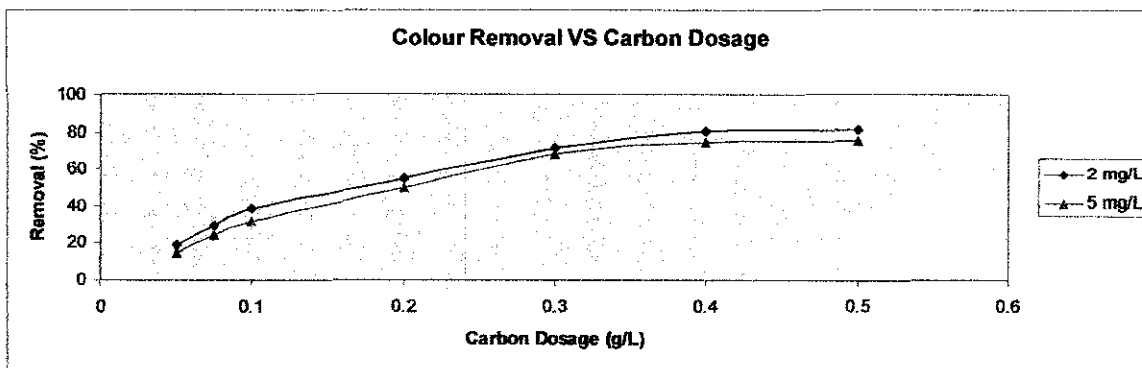


Figure 5 : Effect of carbon dosage on the adsorption of Cibacron Yellow C5G dyes by activated carbon

A number of isotherm equations describe the adsorption process such as Freundlich and Langmuir. Linearised plot of Freundlich and Langmuir equations for 2 mg/L and 5 mg/L of CYC5G are shown in Figure 6, 7, 8 and 9 respectively. The summary of intercept, slope and constant values for Langmuir and Freundlich is shown in Table 4. It was observed that it has significantly effect the concentration of the textile dyes when the dosage of activated carbon from coconut coir is increased.

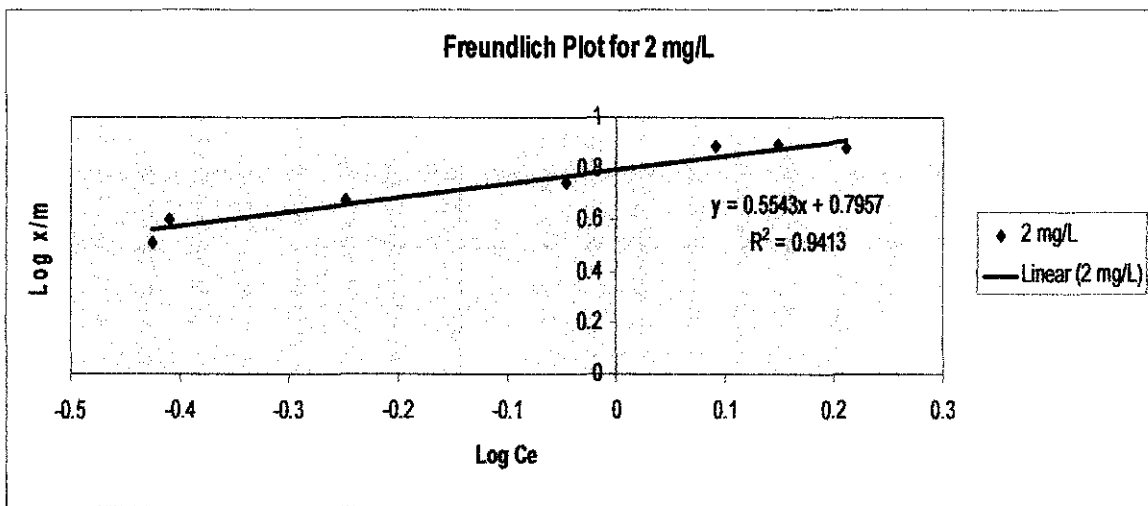


Figure 6 : Freundlich Plot Isotherm for 2 mg/L CYC5G.

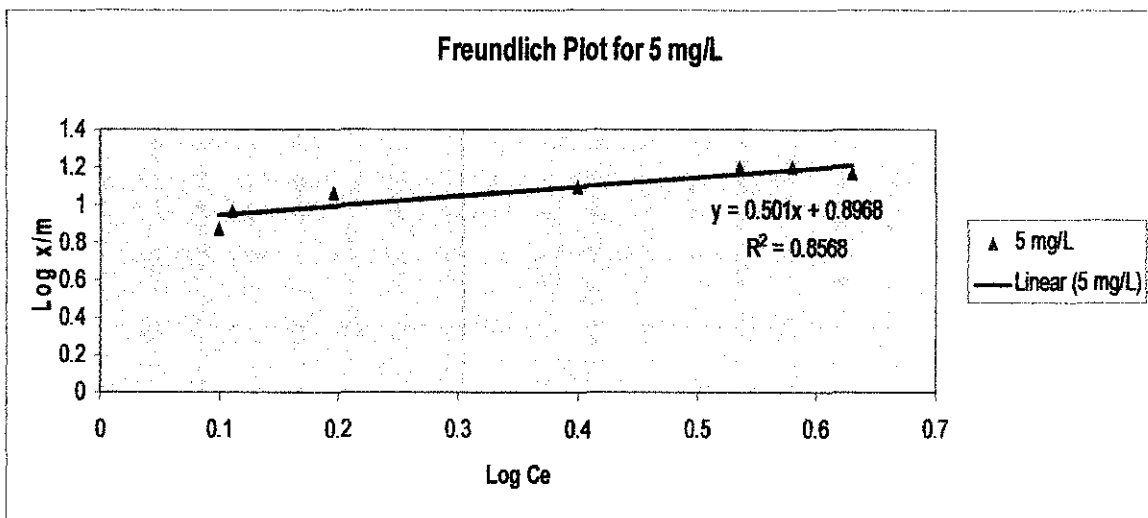


Figure 7 : Freundlich Plot Isotherm for 5 mg/L CYC5G.



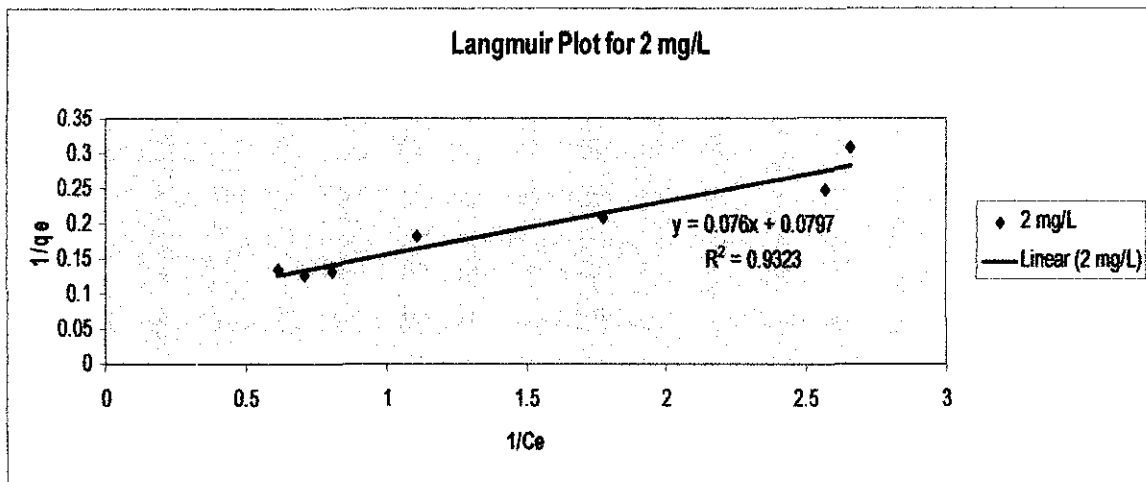


Figure 8 : Langmuir Plot Isotherm for 2 mg/L CYC5G.

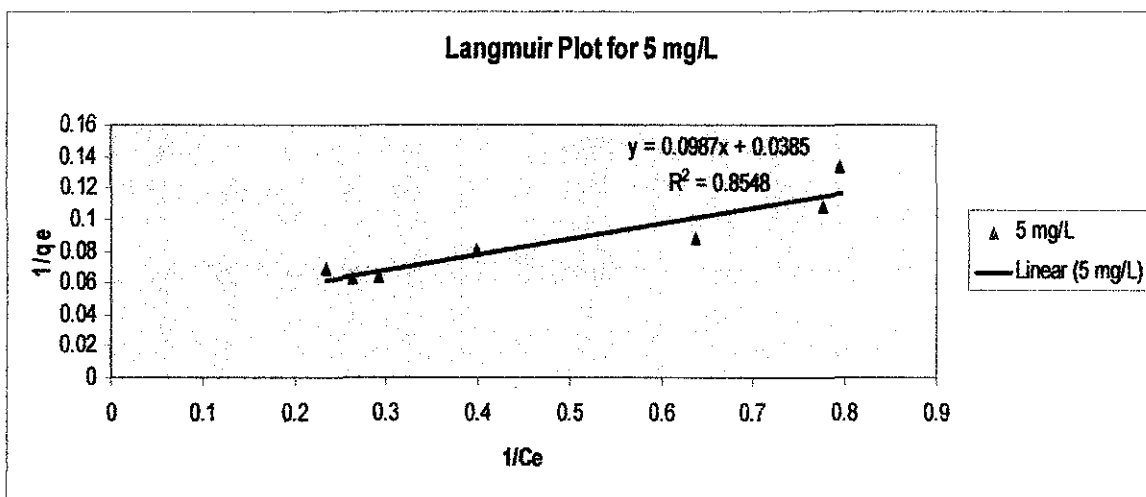


Figure 9 : Langmuir Plot Isotherm for 5 mg/L CYC5G

Table 4 : Intercept, slope and constant values of Freundlich and Langmuir isotherm

<b>Freundlich Isotherm</b>				
<b>Concentration</b>	<b>Equation</b>	<b><math>R^2</math></b>	<b><math>1/n</math></b>	<b><math>K_f</math></b>
2 mg/L	$y = 0.5543x + 0.7957$	0.9413	0.5543	6.247
5 mg/L	$y = 0.501x + 0.8968$	0.8568	0.501	7.885
<b>Langmuir Isotherm</b>				
<b>Concentration</b>	<b>Equation</b>	<b><math>R^2</math></b>	<b><math>q_m</math></b>	<b><math>b</math></b>
2 mg/L	$y = 0.076x + 0.0797$	0.9323	12.547	1.049
5 mg/L	$y = 0.0987x + 0.0385$	0.8548	25.974	0.39

## Column studies

### *Effect of flow rate*

Dye solution with concentration of 5 mg/L at pH 2 was used as influent in this study. A uniform cross sectional area column was packed with the granular form of coconut coir carbon (GCCC). The volumetric flow rate was directly proportional to overall linear flow through the bed. The packed of GCCC in the column was set to 30 cm of column height which weight of 125 gram. The Cibacron Yellow C5G dye solution was allowed to flow through the carbon bed at different flow rates such as 10 mL/min and 20 mL/min. At every 15 minutes interval, the effluent was collected and analysed for the respective residual dye concentration. The breakthrough curve at different flow rates and constant bed depth is shown in Figure 10. It has shown from the figures, by the increased of flow rate, the service times were shortened due to decreased contact time between the dye and carbon at higher flow rates. Premature breakthrough occurred as the adsorption was diffusion controlled.

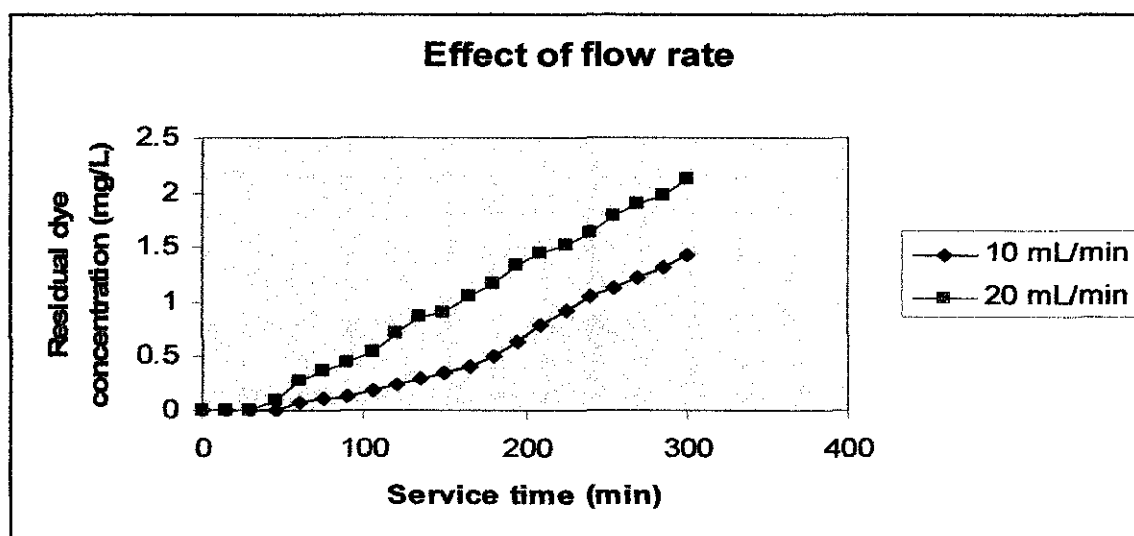


Figure 10 : Breakthrough curve at different flow rates and constant bed depth for 5 mg/L Cibacron Yellow C5G textile dye

### *Effect of bed depth*

The breakthrough curve for Cibacron Yellow C5G textile dye at different bed depths is shown in Figure 11. From the figure, it has shown that as the bed depth increased, the volume of textile dye treated also increased indicating the availability of more carbon surface for adsorption process.

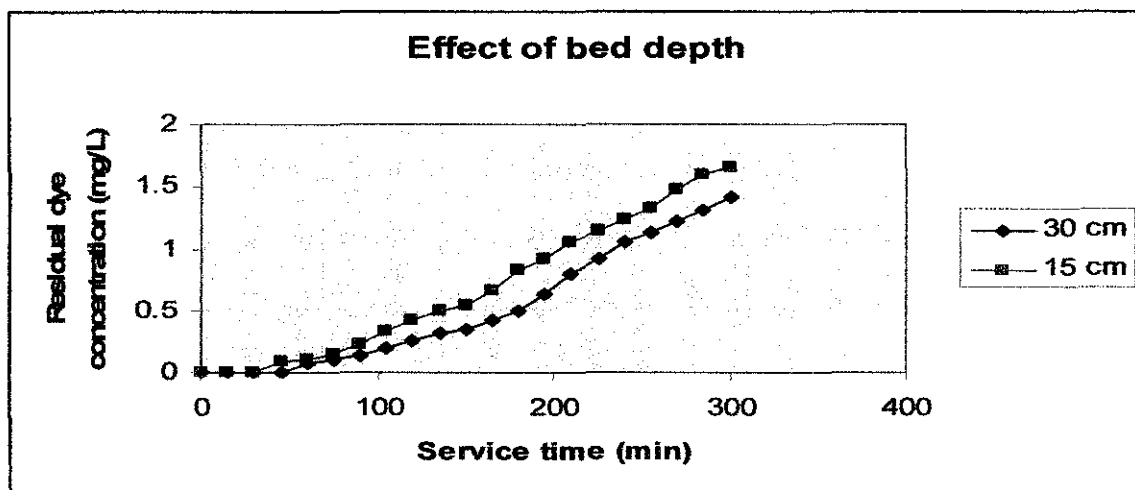


Figure 11 : Breakthrough curve at different bed depth and constant flow rate for 5 mg/L Cibacron Yellow C5G dye

During the treatment of coconut coir with concentrated sulphuric acid ( $H_2SO_4$ ), the colour of the coconut coir turned black. This was caused due to the concentrated sulphuric acid burned the coconut coir. Activated carbon was prepared in a furnace with temperature of  $800^\circ C$  with absence of oxygen (argon atmosphere) and it was sieved to obtain particle with size range of  $325-500 \mu m$  and used in the study. For the time being, a standard curve shown  $R^2=0.9983$ . Adsorption studied had been made on pH study, initial and concentration time study and Freundlich and Langmuir adsorption isotherm.

### Adsorption Isotherm

Adsorption isotherm data are quantified using empirical or theoretical equations since they described the interactions between the adsorbate and adsorbent and so, are critical optimizing the use of adsorbent.

Freundlich and Langmuir equation is being used to describe the adsorption process in this study. Colour adsorption from Cibacron Yellow C5G aqueous solution has been fitted to Freundlich isotherm models. ( T. S Singh, 2006). The Freundlich isotherm equation is given as :

$$q_e = KC_e^{(1/n)} \quad (1)$$

The above equations is linearized to determine the constants by using logarithm as given below :

$$\log(q_e) = \log(K) + \frac{1}{n} \log(C_e) \quad (2)$$

Where  $q_e = \frac{x}{m}$ ; is the amount adsorbed in mg/g, K and n are Freundlich constants. And  $C_e$  is the equilibrium concentration of the dye solution. Straight line plots of  $\log q_e$  (log

x/m) VS log C<sub>e</sub> was shown in Figure 6 and 7. The empirical constant K and 1/n determined from the slope and intercept obtained from the straight line as summarized in Table 4.

The adsorption isotherm also has been fitted to Langmuir equation. It is a two parameter equation as given below :

$$q_e = \frac{bq_m C_e}{1 + bC_e} \quad (3)$$

To determine the parameters the linearized form of the above equation was used :

$$\frac{1}{q_e} = \frac{1}{bq_m C_e} + \frac{1}{q_m} \quad (4)$$

The constant value of q<sub>m</sub> and b were obtained from the slope and intercept of the plot of 1/q<sub>e</sub> and 1/C<sub>e</sub> (Figure 8 and 9) and constant value of q<sub>m</sub> and b (Table 4) are related to energy adsorption capacity and adsorption, respectively.

In the column study, flow rate of influent (Cibacron Yellow C5G) was taken into consideration that gives significant effect to efficiency and column pack of granular coconut coir activated carbon due to contact time between the adsorbent and the textile dye with change in flow rate of 10 mL/min and 20 mL/min. These results show an inverse relationship between the textile dye flow rate and initial breakthrough time as well as bed exhaustion time. The increase in flow rate decreases the volume treated until breakthrough and therefore the service time of the bed.

### **BDST Analysis**

The bed depth service time (BDST) was proposed in linear relationship by Hutchins (1974) between bed depth and service time given by equation :

$$t = \frac{N_o Z}{C_o V} - \frac{1}{C_o K} \ln\left[\left(\frac{C_o}{C_b}\right) - 1\right] \quad (5)$$

where ;

t = service time in minutes

$N_o$  = residual adsorbing capacity per unit volume of bed in  $\text{kg/m}^3$

Z = bed depth in cm

$C_o$  = initial concentration in mg/L

$C_b$  = final concentration in mg/L

V = linear flow velocity in m/h

K = adsorption rate constant in  $\text{m}^3/\text{kg.h}$

Parameters to find service time is shown in Table 5 and the BDST plot for 5 mg/L CYC5G is shown in Figure 12. The linear plot obtained indicates that, when parameters are maintained constant, the volume of effluent treated was a direct function of bed depth.

Table 5 : Values of parameters for linear relationship of BDST analysis

Z (cm)	K ( $\text{m}^3/\text{kg.h}$ )	$N_o$ ( $\text{kg/m}^3$ )	$C_o$ (mg/L)	$C_b$ (mg/L)	V (m/h)	t (min)
15	361.45	2357.85	5.0	1.66	33.95	417.6
30	422.54	2357.85	5.0	1.42	33.95	210.4

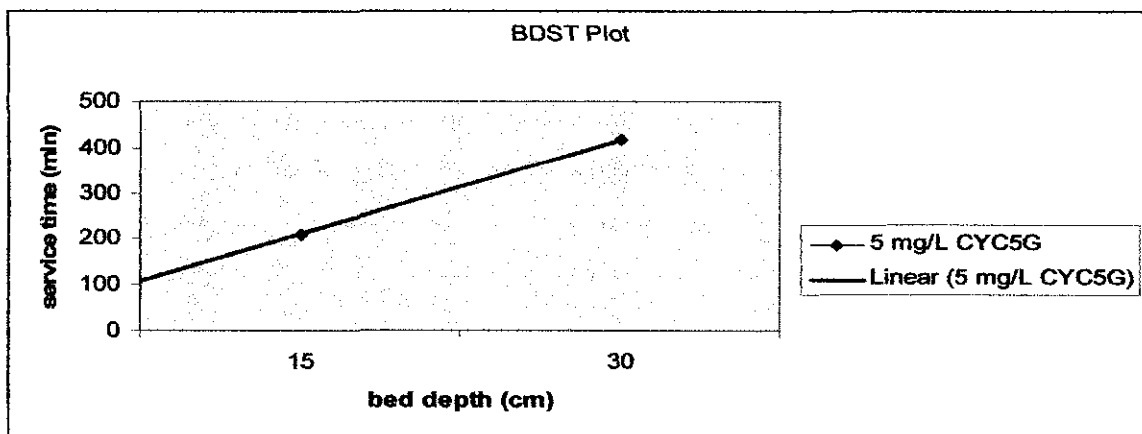


Figure 12 : BDST plot for 5 mg/L concentration of Cibacron Yellow C5G

## **CHAPTER 5**

### **CONCLUSIONS AND RECOMMENDATION**

This project shows that coconut coir activated carbon can be used to remove textile dyes (Cibacron Yellow C5G) from aqueous solution. Adsorption of dye was found to be dependent on initial dye concentration, solution pH and carbon dosage. It is found to be maximum removal of 82.55 and 73.3 % in 0.1 g coconut coir activated carbon for 5 hours contact time in 2 mg/L and 5 mg/L of CYC5G concentration respectively. The adsorption data fitted well to Freundlich and Langmuir models. Maximum adsorption capacity of 4.028 and 9.278 mg/g of coconut coir activated carbon were observed at an adsorbent dose of 0.4 g/L in 2 mg/L and 5 mg/L of CYC5G concentration respectively. The breakthrough curves calculated from the adsorption of dye by these adsorbents in column studies indicate that the dye removal is strongly dependent on flow rate of the solution and carbon bed depth. Adsorption is greater at the slow rate of flow and in thicker bed depth. It is hoped that the coconut coir carbon will be a suitable material for treating the wastewater contaminated with textile dyes in Malaysia.

## References :

- Abadulla, E., Tzanov, T., Costa, S., Robba, K., Cavaco-Paulo, Artur & Bitz, M. G. 2000 Decolorization and detoxification of textile dyes with a laccase from *Trametes hirsute*, *Applied and Environmental Microbiology* **66(8)** : 3357–3362
- Asgher, M., Shah, S. A. H. & Legge, R. L. 2006 Decolorization of some reactive textile dyes by white rot fungi isolated in Pakistan, *World Journal of Microbiology & Biotechnology* **22** : 89–93
- Bechtold, T., Burtscher, E. & Hung, Y. H. 2006 Treatment of textile wastes, *Topics Electrochemical* **6** : 380–414
- Bousher, A., Shen, X. & Edyvean, R. G. J. 1997 Removal of coloured organic matter by adsorption onto low cost waste materials, *Water Research* **31** : 2084–2092
- Cussler, E. L. 1997 Diffusion, *Mass Transfer in Fluid Systems* **40(2)** : 308–330
- Edward, J. C. 2000 Investigation of color removal by chemical oxidation for three reactive textile dyes and spent textile dye wastewater, *Thesis submitted to the faculty of Virginia Polytechnic Institute and State University* : 1–46
- Elliott, C., Colby T., Kelly T. & Hicks H. 1989 Charcoal lung. Bronchiolitis obliterans after aspiration of activated charcoal, *Chest Journal* **96 (3)**: 672–4
- Engber, Daniel 28 Nov 2005 [http://en.wikipedia.org/wiki/Activated\\_carbon](http://en.wikipedia.org/wiki/Activated_carbon)
- Ericson, A. C. & Posner S. 1996 Relative absorbance and reflectance measurements of dye solutions and dyed fabrics, *Textile Chemical Color* **28** : 23–27
- Hutchins, R. A. 1974 New method simplifies design activated carbon systems, *Chemical Engineering* **80** : 133–138
- Laszo, J.A. 1996 Preparing an ion exchange resin from sugarcane bagasse to remove reactive dye from wastewater, *Textile Chemical Color* **85** : 13–17
- Majewska-Nowak, K., Winnicki, T. & Wisniewski, J. 1989 Effect of flow conditions on ultrafiltration efficiency of dye solutions and textile, effluents *Desalination* **71** : 127–135
- Manju, G. N., Raji, C. & Anirudhan, T. S. 1998 Evaluation of coconut husk carbon for the removal of arsenic from water, *Water Research* **32(10)** : 3062 – 3070



Poots, V. J. P., McKay, G. & Healy, J. J. 1976 Removal of basic dyes from effluents using wood as an adsorbent, *Journal of Water Pollution Control Federation* **50(2)** : 926-935

Provost, J.R. 1992 Effluent improvement by source reduction of chemicals used in textile printing, *Journal Dyers Colour* **108** : 260–264

Rabin, M. W., Swann W. C. & Gilbert S. L. 2002 Interleaved, sampled fiber Bragg gratings for use in hybrid wavelength references, *Applied Optics* **41** : 7193-7196

Santhy, K. & Selvapathy, P. 2006 Removal of reactive dyes from wastewater by adsorption on coir pith activated carbon, *Bioresources Technology* **97(2006)** : 1326-1336

Schramm, W. & Jantschgi, J. 1999 Comparative assessment of textile dyeing technologies from a preventive environmental protection point of view, *Journal Dyers Colour* **115(6)** :130–135

Shu, H., Huang, C. & Chang, M. 1994 Decolorization of Mono-Azo Dyes in Wastewater by Advanced Oxidation Processes, *A Case Study of Acid Red 1 and Acid Yellow 23*. *Chemosphere* **29** : 2597-2607.

Singh, T. S. 2006 Investigation on reduction of colour from pulp and paper mill effluent by activated coconut jute carbon, *Journal of Water Supply:Research and Technology-AQUA* **55(1)** : 57-63

Walker, G. M. & Weatherley, L. R. 2001 Adsorption of dyes from aqueous solution-the effect of adsorbent pore size distribution and dye aggregation, *Chemical Engineering Journal* **83 (2001)** : 201–206

# APPENDIX

**Table A1 : Adsorption isotherm study (Langmuir and Freundlich) of 2 mg/L Cibacron Yellow C5G at pH 2 and 5 hours contact time**

<b>Carbon dosage, m</b>	<b>Final concentration, Ce</b>	<b>Removal</b>	<b>Adsorbent undertake by dye(x)</b>	<b>Amount adsorb (x/m)</b>	<b>Log qe (log x/m)</b>	<b>Log Ce</b>	<b>1/qe</b>	<b>1/Ce</b>
<b>g/L</b>	<b>mg/L</b>	<b>%</b>	<b>mg</b>	<b>mg/g</b>				
0.05	1.624	18.8	0.376	7.52	0.876218	0.210586	0.132979	0.615764
0.075	1.409	29.55	0.591	7.88	0.896526	0.148911	0.126904	0.709723
0.1	1.235	38.25	0.765	7.65	0.883661	0.091667	0.130719	0.809717
0.2	0.899	55.05	1.101	5.505	0.740757	-0.04624	0.181653	1.112347
0.3	0.564	71.8	1.436	4.786666667	0.680033	-0.24872	0.208914	1.77305
0.4	0.389	80.55	1.611	4.0275	0.605036	-0.41005	0.248293	2.570694
0.5	0.376	81.2	1.624	3.248	0.511616	-0.42481	0.307882	2.659574

**Table A2 : Adsorption isotherm study (Langmuir and Freundlich) of 5 mg/L Cibacron Yellow C5G at pH 2 and 5 hours contact time**

<b>Carbon dosage, m</b>	<b>Final concentration, Ce</b>	<b>Removal</b>	<b>Adsorbent undertake by dye(x)</b>	<b>Amount adsorb (x/m)</b>	<b>Log x/m</b>	<b>Log Ce</b>	<b>1/qe</b>	<b>1/Ce</b>
<b>g/L</b>	<b>mg/L</b>	<b>%</b>	<b>mg</b>	<b>mg/g</b>				
0.05	4.27	14.6	0.73	14.6	1.164353	0.630428	0.068493	0.234192
0.075	3.804	23.92	1.196	15.94666667	1.20267	0.580241	0.062709	0.262881
0.1	3.432	31.36	1.568	15.68	1.195346	0.535547	0.063776	0.291375
0.2	2.516	49.68	2.484	12.42	1.094122	0.400711	0.080515	0.397456
0.3	1.568	68.64	3.432	11.44	1.058426	0.195346	0.087413	0.637755
0.4	1.289	74.22	3.711	9.2775	0.967431	0.110253	0.107788	0.775795
0.5	1.258	74.84	3.742	7.484	0.874134	0.099681	0.133618	0.794913

**Table A3 : Column studies for different bed depth and flow rate**

Service time minutes	30cm bed depth		15cm bed depth
	10mL/min	20mL/min	10mL/min
0	0	0	0
15	0	0	0
30	0	0	0
45	0	0.1	0.093
60	0.082	0.28	0.11
75	0.11	0.37	0.15
90	0.14	0.46	0.23
105	0.19	0.55	0.33
120	0.25	0.71	0.42
135	0.31	0.86	0.49
150	0.35	0.91	0.54
165	0.42	1.06	0.66
180	0.5	1.17	0.83
195	0.63	1.34	0.92
210	0.79	1.44	1.05
225	0.92	1.52	1.14
240	1.05	1.63	1.24
255	1.13	1.78	1.32
270	1.22	1.9	1.47
285	1.31	1.97	1.59
300	1.42	2.12	1.66

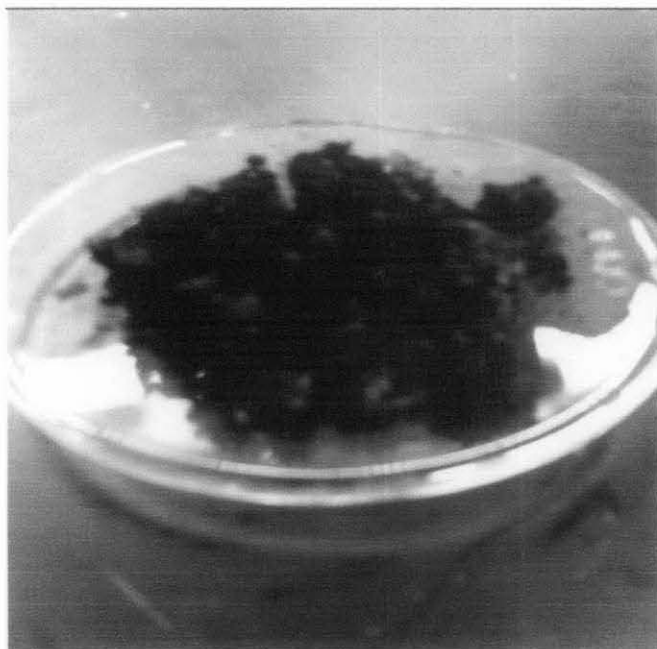


Figure A1 : Coconut coir carbon

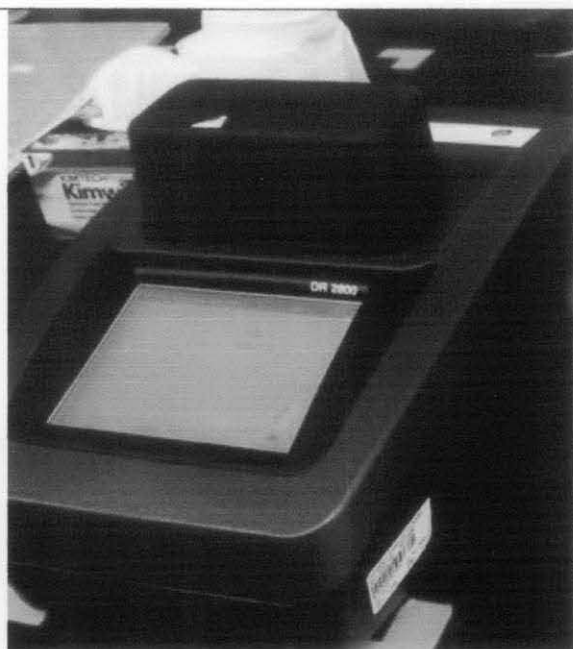


Figure A2 : DR2800 Spectrophotometer

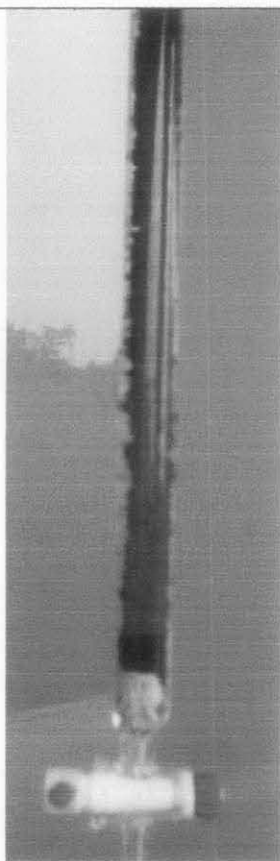


Figure A3 : Column pack with granular coconut coir carbon



Figure A4: Pump for flow rate control