Removal of Dye in Wastewater via Adsorption Using Agricultural Waste (Natural Sorbent)

by

Melissa Suraya binti Mustfha

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Chemical Engineering)

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CERTIFICATION OF APPROVAL

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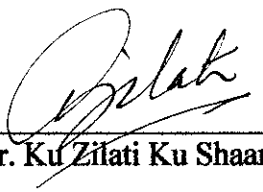
Approved by,



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January 2009

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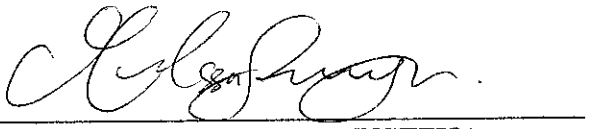

MELISSA SURAYA BINTI MUSTFHA

ABSTRACT

Dye is a coloring agent that is widely used by some of the industries. The color removal from the effluent water has been one of the concerns during the wastewater treatment process. This is to overcome any adverse effect caused from the releasing of the dye to the inland waters. Various separation techniques have been proposed to remove the dye and it is revealed that adsorption is one of the most effective techniques. Anyway, researches have been made to identify potential adsorbent that is low in cost to be the adsorbent for the separation process undertaken. This is done in order to replace the activated carbon used as the adsorbent, due to its high cost. The objective of this study is to investigate the potential of natural sorbent from agricultural waste in removing dye in wastewater. Two agricultural wastes are proposed to be the adsorbent which are oil palm leaves and corn husks. These adsorbents are easily available and not bulky to be handled. Furthermore, the recycling opportunities of this waste can be developed. Parameters such as adsorbent particle size, mass of adsorbent and initial dye concentration that will affect the dye removal via adsorption will be studied. The adsorbate used in this study is Methylene Blue. Different methods for different type of experiment are explained further in this report. From the study, it is found that smaller particle size, higher adsorbent mass and higher dye initial concentration will enhance the adsorption process. In conclusion, the proposed adsorbents which are the oil palm leaves and corn husk proven to have the potential in removing dye from wastewater. Recommendations of further work are also mention for continuity of this type of research.

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INTRODUCTION

1.1 Background Study.

Dye can be generally described as the colored substance that has an affinity to the substrate to which it is being applied. It is a coloring agent that is widely used in industries such as textiles, rubber, paper, plastic and cosmetic. V.K Garg (2003) state, color is the first contaminant to be recognized in water and has to be removed from wastewater before discharging it into water bodies. Most of the industries in India, which are textile, paper printing, leather, food, and cosmetics, use dyes to color their final product. Such industries do available in Malaysia. In the dyeing section of a textile industry, about 1000L of water is used for every 1000kg clothes processed. Discharged of such color effluents imparts color to the receiving water bodies such as rivers and lakes and will interfere with its intended beneficial use.

For a long time, treatments of effluents have concentrated mainly on two aspects, which are:

i – Regeneration of concentrated effluent with regards to saving of chemicals.

ii – Lowering of chemical costs and treatment of effluent with high toxicity.

Over the last decade, the situation has changed and limits of a considerable number of compounds and parameters have been defined to avoid problems with regards to biotoxicity, heavy metal content, corrosion problems and total Chemical Oxygen Demand (COD) / Biological Oxygen Demand (BOD) load in the release effluents. Table 1 shows an extract of important parameters for wastewater in textile plant as defined by Austrian Government as well as limits defined for both direct release to surface water and for release into Chemical Wastewater Treatment (CWWT). The treatment of colored effluents is not restricted to the reduction of ecological parameters only but also to the reduction of dye concentrations in the effluent.

Table 1: Specification limit for textile wastewater by Austrian Government.

Table 1 Representative Limits Defined for Release of Textile Waste Water

Limits for emission	Release into river	Release into CWWT
General parameters		
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
Color, spectral coefficient of extinction:		
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
Inorganic parameters (mg/L)		
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
Organic parameters (mg/L)		
TOC (total organic carbon as C)	50	> 70 % biodegradation
COD (chemical oxygen demand as O_2)	150	> 70 % biodegradation
BOD_5 (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

Image from: Anon et al, 1992

Generally, dyes containing wastewaters can be treated in two ways, which are physical and chemical methods of dye removal (decoloration process) and by means of biodegradation. As for that, various chemical and physical methods have been proposed for the removal of dye from the effluent water. Those techniques are nanofiltration, electrokinetics coagulation, liquid-liquid extraction, ozonation, biological process and adsorption. Table 2 shows several reported method for dye removal. Each technology has its own advantages and drawback.

Table 2: Technologies use in dye removal.

Principal existing and emerging processes for dyes removal

	Technology	Advantages	Disadvantages
Conventional treatment processes	Coagulation Flocculation	Simple, economically feasible	High sludge production, handling and disposal problems
	Biodegradation	Economically attractive, publicly acceptable treatment	Slow process, necessary to create an optimal favorable environment, maintenance and nutrition requirements
	Adsorption on activated carbons	The most effective adsorbent, great, capacity, produce a high-quality treated effluent	Ineffective against disperse and vat dyes, the regeneration is expensive and results in loss of the adsorbent, non-destructive process
Established recovery processes	Membrane separations	Removes all dye types, produce a high-quality treated effluent	High pressures, expensive, incapable of treating large volumes
	Ion-exchange	No loss of sorbent on regeneration, effective	Economic constraints, not effective for disperse dyes
	Oxidation	Rapid and efficient process	High energy cost, chemicals required
Emerging removal processes	Advanced oxidation process	No sludge production, little or no consumption of chemicals, efficiency for recalcitrant dyes	Economically unfeasible, formation of by-products, technical constraints
	Selective bioadsorbents	Economically attractive, regeneration is not necessary, high selectivity	Requires chemical modification, non-destructive process
	Biomass	Low operating cost, good efficiency and selectivity, no toxic effect on microorganisms	Slow process, performance depends on some external factors (pH, salts)

Image from: G. Crini, 2004.

Among those, adsorption has been found to be the superior compared to the others techniques. It is due to its capability for efficiently adsorbing a broad range of adsorbates and its simplicity of design. The adsorbents suitable for wastewater treatment plant are dead plant and animal matter called biomass; including charcoals, activated carbon, clays, soils, diatomaceous earth, activated sludge, compost, living plant communities, polymer synthesized from petrochemicals and inorganic salt coagulants (Laszlo J. A., 1994).

Most widely used adsorbent are activated carbon. However, the uses of activated carbon as the adsorbent are still considered as an expensive material. Therefore, there is a need to find out much economical, effective, viable alternative adsorbent. As for that, natural materials, waste materials from industry or domestic uses and agricultural and biosorbent can be obtained and employed as an inexpensive adsorbent.

1.2 Problem Statement.

Spent dye solutions from textile dyeing operations ultimately are discharged to surface water after some form of wastewater treatment and dyes are not effectively removed from the wastewater may result in environmental and human exposure (Lynch et al, 2000). The release of dyes into waters poses serious environmental and health issues. These happened due to various dyes persistent and recalcitrant nature. Color impedes light penetration, retards photosynthetic activity, inhibits the growth of biota and also has tendency to chelate metal ions which produce micro-toxicity to fish and other organisms (Mckay G. et al, 1980). Direct discharge of dyes containing effluents into municipal wastewater plant and environment may also cause formation of toxic carcinogenic breakdown products. It also should be noted that the contamination of drinking water by dyes at even a concentration of 1.0 mg/L could impart significant color, making it unfit for human consumption. Therefore, the color removal from the effluent water becoming an important objective of wastewater treatment processes. This goal is pursued not only because the legislation requirement become more stringent but also if the water quality for recycle purposes is taken into account. Several physical or chemical processes are used to treat dye laden wastewaters. However, these processes cannot effectively be used to treat the wide range of dye in the effluent. The alum coagulation process is ineffective for the treatment of azoic, reactive, acidic and basic dyes. Conventional biological processes are effective for basic dye removal only (Banat IM et al, 1996). As synthetic dyes in effluent cannot be effectively decolorized, the adsorption on inexpensive and efficient solid supports was considered as a simple and economical method for their removal from water and wastewater (E. Forgacs et al, 2004). Activated carbon (powdered or granular) is the most widely used adsorbent because it has excellent adsorption efficiency for organic compounds but its use is usually limited due to its high cost. This has motivated the search of alternatives adsorbents especially from the agricultural waste. As for the adsorbent proposed for this research, both have minimal further uses. The oil palm leaves are usually being leftover or burned at the plantation area and the corn husks are usually made into doll or wrapping paper.

1.3 Objective & Scope of Study.

This study focuses on the removal of dye in wastewater via adsorption using agricultural by-product. The objectives of the study are as follows:

i. To investigate the potential of using natural sorbents in removing dye in wastewater. Proposed adsorbents are oil palm leaves and corn husk.

ii. To study the effect of mass of adsorbent, adsorbent particle size and initial dye concentration on the adsorption ability.

iii. To develop recycling opportunity of the agricultural wastes.

The scopes of the study are as below:

i. To study the effect of adsorbent particle size to the adsorption process.

ii. To study the effect of adsorbent mass to the adsorption process.

iii. To study the effect of initial dye concentration to the adsorption process.

1.4 Feasibility of Research Study.

The feasibility study of the project within the scope is to get the best way how to manage the entire task in completing the research project in 2 semesters provided. Planning schedule is developed in order to have good planning in completing the entire task in the study. The planning schedule is attached in Appendix 1. The performance of using both natural sorbent to adsorb dye will be asses throughout the study and generally, the effectiveness of those adsorbent can be determined.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview.

Within this chapter, the details on decoloration, adsorption process, adsorbent and adsorbate will be explained further. Adsorbents that are used in some of the previous study on dye adsorption are stated. Beside that, the previous findings on the effect of the adsorbent particle size, adsorbent mass and initial dye concentration, which will also be studied in this research are also discuss in this chapter.

2.2 Decoloration.

Clarke et al, (1995) stated that the legislation about toxic substances in industrial wastewaters is becoming increasingly strict; consequently, a large number of researchers are addressing the variety of issues in this area. The greatest environment polluter is the chemical industry, of which only a relatively small part pertains to the organic colorants industry (3 – 4 %). The treatment of colored wastewaters (mostly resulting from finishing plants) therefore is not restricted to the reduction of ecological parameters only [such as chemical oxygen demand (COD), biological oxygen demand (BOD), total organic carbon (TOC), adsorbable organic halide (AOX), temperature and pH], but also to reduction of dye concentrations in the wastewater (Gregor et al, 1993). Strickland et al, (1995) mentioned that the color of water, polluted with organic colorants, reduces when cleavage of the –C=C- bonds, the –N=N- bonds and the heterocyclic and aromatics rings occurs. The absorption of light by the associated molecules shifts from the visible to the ultraviolet or infrared region of the electro magnetic spectrum. The methods to decoloration are divided into physical methods, biological methods and chemical methods. The list of all these three methods are stated by Slokar et al, (1997) in their study, Physical methods include different precipitation methods (coagulation, flocculation, sedimentation), adsorption (on activated carbon, biological sludge, silica

gel), filtration, reverse osmosis, etc. Biological treatments differ according to the presence or the absence of oxygen. In the former case the process is called aerobic (revival of biological sludge in aeration basins) and in the latter anaerobic treatment (decay and rot in stabilizing lagoons). Chemical treatments are those, in which chemicals needed for decoloration of wastewater are used, and include reduction, oxidation, complexiметric methods, ion exchange and neutralization.

2.3 Adsorption.

Adsorption is a separation process where one or more components of a gas or liquid stream adsorbed on the surface of a solid adsorbent. The fluid is passed through the adsorbent and the solid particles adsorb the components from the fluid. Adsorption is the process of accumulating substances that are in solution on a suitable interface. It also can be defined as a mass transfer operation in that a constituent in the liquid phase is transferred to the solid phase. The adsorption process has not been used extensively in wastewater treatment, but demands for a better quality of treated wastewater effluent, including toxicity reduction, have led to an extensive examination and use of the process of adsorption on activated carbon. (Metcalf et al, 2004). Basar (2006) stated that color removal from industrial wastewaters by adsorption techniques has been of growing importance due to the chemical and biological stability of dyestuffs to the conventional water treatment methods and the growing need for high quality treatment. Adsorption onto activated carbon has been found to be superior for wastewater treatment compared to other physical and chemical techniques, such as flocculation, coagulation, precipitation and ozonation as they possess inherent limitations such as high cost, formation of hazardous by-products and intensive energy requirements (Padmesh, et al, 2006). Gregorio Crini (2004) quoted that adsorption techniques are widely used to remove certain classes of pollutants from waters, especially those that are easily biodegradable and dye represents one of the problematic groups.

2.4 Adsorbent.

Activated carbon (powdered or granular) is the most widely used adsorbent because it has excellent adsorption efficiency for organics compound, but its use is usually limited due to its high cost. This is due to the use of non-renewable and relatively expensive starting material such as coal, which is unjustified in pollution control applications (Martin, et al 2003). Therefore, studies have been made in order to search for low cost adsorbents in removing dye in wastewater. Table 3 shows a list of some low cost materials studied for the dye removal.

Table 3: Low cost material studied as adsorbent.

Some low cost materials studied for dye(s) removal from aqueous solutions

Adsorbent(s)	Dye(s)
1. Bamboo dust, coconut shell, groundnut shell, rice husk	Methylene blue
2. Silk cotton hull, coconut tree sawdust, sago waste, maize cob	Rhodamine-B, Congo red, methylene blue, methyl violet, malachite green
3. *Parthenium hysterophorus*	Methylene blue, malachite green
4. Rice husk	Malachite green
5. Coir pith	Acid violet, acid brilliant blue, methylene blue, Rhodamine-B
6. Orange peel	Acid violet 17
7. Indian Rosewood	Malachite green
8. *Prosopis cineraria*	Malachite green
9. Banana and orange peels	Methyl orange, methylene blue, Rhodamine-B, Congo red, methyl violet, acid black 10B
10. Giant duckweed	Methylene blue
11. Banana pith	Congo red, Rhodamine-B, acid violet, acid brilliant blue
12. Orange peel	Congo red, Rhodamine-B, Procion orange
13. Carbonized coir pith	Acid violet, Rhodamine-B
14. Hardwood	Astrazone blue
15. Chitosan	Acid blue 25, basic blue 69
16. Chitin	Acid blue 25, basic blue 69
17. Biogas residual slurry	Congo red, Rhodamine-B, acid violet, methylene blue
18. Plum kernels	Basic red 22, acid blue 25
19. Rice husk	Safranine, methylene blue
20. Wheat straw, corn cob, barley husk	Chacron yellow C-2R, Chacron red C-2G, Chacron blue C-R, Remazol black B, Remazol red-RB
21. Mahogany sawdust, rice husk	Acid yellow 36
22. Activated sludge biomass	Basic blue 3, basic violet 3, basic red 18, basic yellow 24, basic red 29, basic blue 47, basic blue 54
23. Fly ash	Acid orange 7, acid yellow 23, disperse blue 79, basic yellow 28, direct yellow 28
24. Perlite	Victoria blue, methyl violet
25. Fuller's earth	Methylene blue
26. Kaolinite	Methylene blue
27. Activated clay	Acid blue 9
28. Calcinated alunite	Acid blue 40, acid yellow 17
29. Cement kiln dust	Basic blue 3, basic red 22
30. Neem leaf powder	Brilliant green

Image from: Garg et al, 2004

2.4.1 Oil Palm Leaves

Malaysia is the largest exporter of oil palm oil in the international market. One of the significant problems in the oil palm fruit processing is managing of the wastes generated during the processes (Z. Husain, et al, 2003).

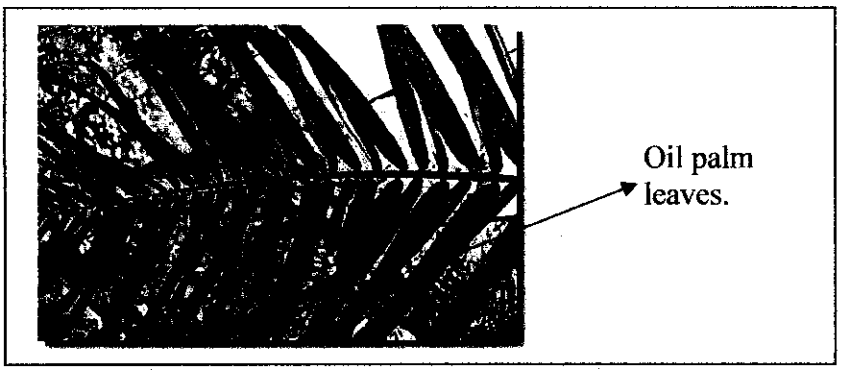


Figure 1: Oil palm frond.

Oil palm leaves are the parts that are attached to the oil palm frond as shown in figure 1. It has been reported that (reference), in January 2006 itself, the total wastes that include oil palm trunks, oil palm fronds, empty fruit bunch and oil palm shell from the oil palm industries are 3.96 million tons. Therefore, this indicates that oil palm leaves are widely and economically available to be used as an adsorbent in removing dye from the waste water.

2.4.2 Corn Husk.

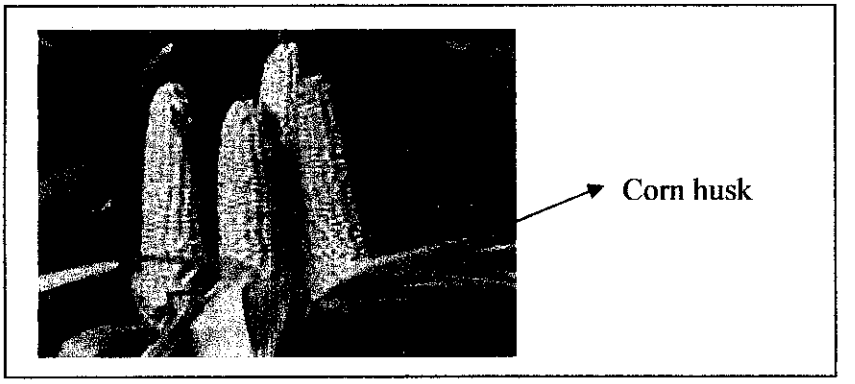


Figure 2: Maize / Corn

Figure 2 shows the green outer layer which covers the Maize / corn (Zea mays ssp. mays L.), which is known as corn husk. As the plant matures, the cob becomes tougher until only the kernels are edible. When harvesting corn, the corn cob is collected as part of the ear, leaving the corn stover in the field. Anyway, just the corn kernels can be eaten or used to produce food product. The corncob and corn husk will be left over as a waste. Usually corn husk is being dried and used to produce art related product such as corn doll and corn husk wrappers.

2.5 Adsorbate.

2.5.1 Methylene Blue (MB)

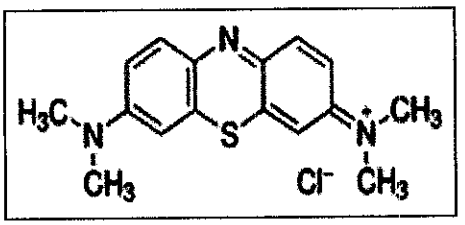


Figure 3: Chemical structure of Methylene Blue (MB).

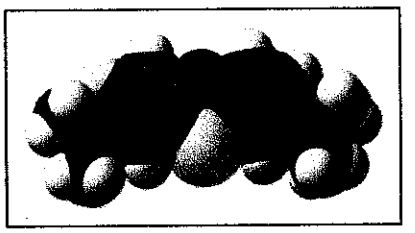


Figure 4: Space-filling model of MB in its oxidized form.

Figure 3 and 4 shows the chemical structure of Methylene Blue (MB) and the space filling model of Mb in its oxidized form, respectively. It is one of the basic dyes used for printing cotton, dyeing and dyeing leather. Its IUPAC is name 3,7-bis(Dimethylamino)-phenazathionium chloride / Tetramethylthionine chloride. A MB can cause eye burn, and if swallowed, its causes irritation to the gastrointestinal tract with symptoms of nausea, vomiting and diarrhea. It may also cause methemoglobinemia, cyanosis, convulsions and dyspnea if inhaled (Senthilkumaar, et al, 2005). It is also can cause formation of toxic carcinogenic breakdown products.

2.6 Findings on Previous Study

2.6.1 Parameter 1: Particle Size

Table 4: Effect of particle size using various kind of adsorbent.

Kinetic parameters for various adsorbents in batch experiments at 20 °C

Adsorbent	d_p (μm)	Dye	C_0 (mg L^{-1})	q_e (mg g^{-1}) experimental
Hazelnut	125	Methylene Blue	1000	76.0
			500	49.0
			250	25.0
Hazelnut	500	Methylene Blue	1000	41.0
			500	37.0
			250	24.0
			50	5.0
Hazelnut	125	Acid Blue 25	500	57.0
			250	49.0
			50	9.2
Hazelnut	500	Acid Blue 25	500	33.0
			250	21.5
			50	7.0
Walnut	125	Methylene Blue	750	57.8
			500	45.0
			50	5.0
Cherry	125	Methylene Blue	750	39.8
			500	39.0
			50	5.0
Oak	125	Methylene Blue	500	29.5
			250	22.8
			50	5.0
Pitch-pine	125	Methylene Blue	500	27.5
			250	22.8
			50	5.0

In the study, the adsorbent is prepared into two particle size ranges which are 75 – 180 μM (dp: 125 μM) and 300 – 710 μM (dp: 500 μM). From the results obtained, it showed that adsorbent with smaller particle size can adsorbed more compared to adsorbent that have much larger particle size.

Image from: F. Ferreno, 2007.

2.6.2 Parameter 2: Mass of Adsorbent.

i. Adsorbent: Indian Rosewood Sawdust

Table 5: Effect of mass of adsorbent on the removal of MB using Indian Rosewood Sawdust

Effect of adsorbent dose on methylene blue removal

Adsorbent dose (g/100 ml)	Percent dye removal with time (min)					
	15	30	45	60	90	120
Sulphuric acid treated sawdust (SDC)						
0.2	22.6	35.8	37.0	40.1	43.4	45.1
0.4	80.0	80.2	81.0	81.1	81.8	82.2
0.6	81.9	82.0	82.1	82.2	82.7	82.9
0.8	85.1	85.2	85.4	85.6	86.2	87.1
1.0	90.6	91.0	91.5	92.6	96.2	97.1
Formaldehyde treated sawdust (SD)						
0.2	11.9	22.8	23.1	24.2	24.6	24.9
0.4	71.0	71.5	72.4	73.5	73.6	73.7
0.6	75.6	77.5	78.2	79.3	79.7	80.4
0.8	80.2	81.1	82.8	82.7	83.6	83.9
1.0	85.5	86.9	90.2	90.6	91.0	91.2

Image from: Garg et al, 2004.

The percentage of adsorption was increased and the equilibrium time decreased with the adsorption dose. The adsorption increased from 45.1% to 97.1%, as the Sulphuric acid treated sawdust (SDC) dose was increased from 0.2 g to 1.0 g / 100 mL at equilibrium time (120 min). For Formaldehyde treated sawdust (SD), adsorption increased from 24.9% to 91.2% as the adsorbent dose was increased from 0.2 g to 1.0 g / 100 mL. Maximum dye removal was achieved within 30 – 45 min after which MB concentration in the test solution was almost constant. Increase in the adsorption with the adsorbent dose can be attributed to increased adsorbent surface area and availability of more adsorption sites (Garg et al, 2004).

2.6.3 Parameter 3: Initial Dye Concentration.

i. Adsorbent: Pineapple stem

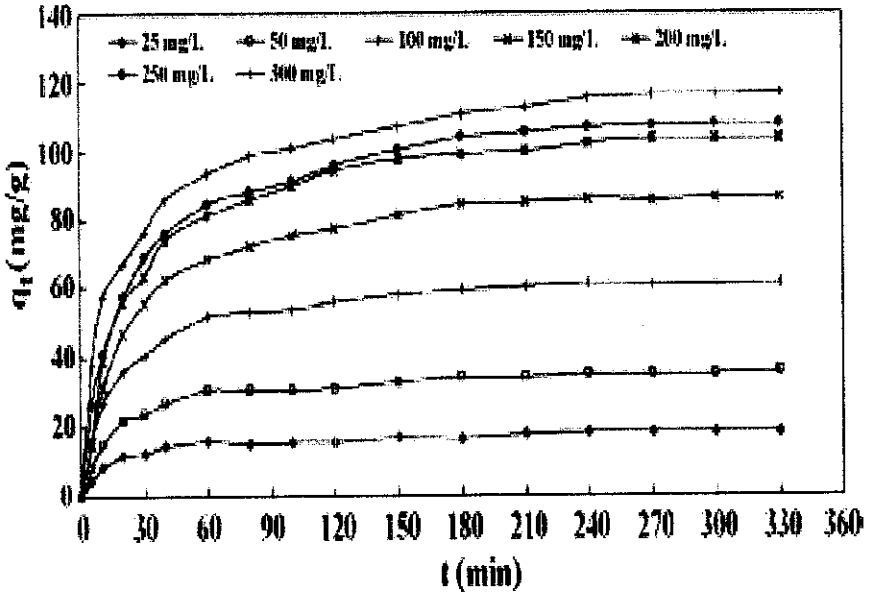


Image from: B.H.Hameed et al, 2008.

Figure 5: Effect of initial concentration on the removal of MB using pineapple stem.

It can be seen that the amount of dye adsorbed (mg/g) increased with the increased in dye concentration and remain constant after equilibrium time. The concentration provides an important driving force to overcome all mass transfer resistance of the dye between the aqueous and solid phases. Hence, higher initial concentration of dye will enhance the adsorption process (B. H Hameed et al, 2008)

ii. Adsorbent: Activated carbon prepared from coconut husk.

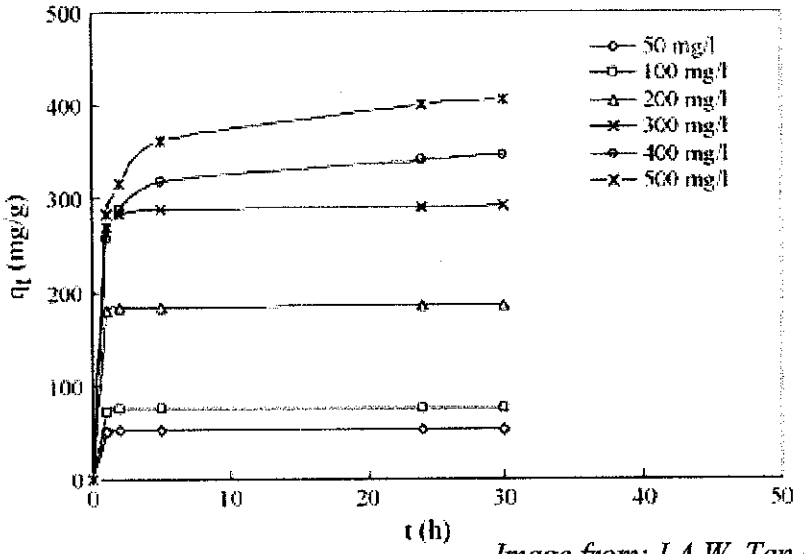


Image from: I.A.W. Tan et al, 2008.

Figure 6: Effect of initial concentration on the removal of MB using activated carbon prepared from coconut husk.

Stated from the study, the contact time needed for MB solutions with initial concentration of 50 – 300 mg/L to reach equilibrium was around 2h. However, the MB solutions with higher initial concentrations of 400 – 500 mg/L and equilibrium times of around 30h were required. Moreover, when the initial concentration increases, the mass transfer driving force becomes larger, thus resulting in higher adsorption of MB (Tan et al, 2008).

CHAPTER 3
METHODOLOGY

3.1 Project Activities

The assessment of *oil palm leaves* and *corn husk* as the two main material or adsorbent for the removal of dye in wastewater via adsorption process are constructed based on several studies and experiments that taken place concurrently with the research paper. A series of experiments were conducted throughout the research study, to investigate:

i - The effect of adsorbent particle size to the adsorption capacity.

ii - The effect of mass of adsorbent to the adsorption capacity.

iii -The effect of initial dye concentration to the adsorption capacity.

Figure 7 summarize the overall research activities.

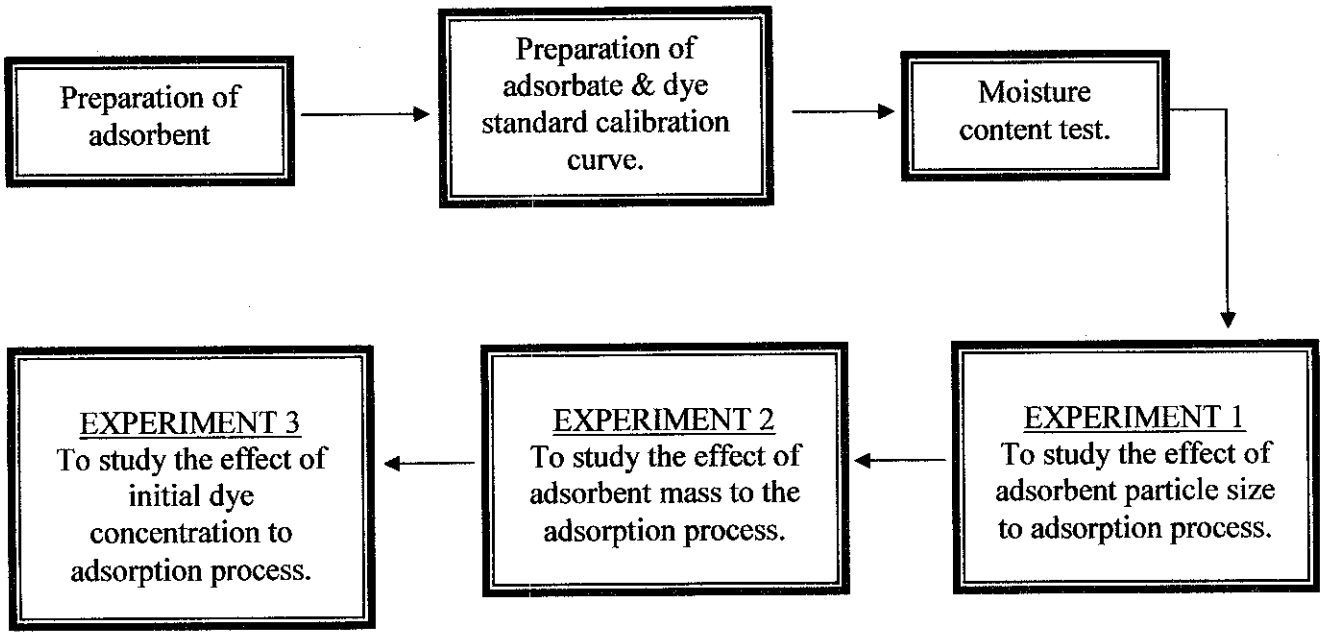


Figure 7: Research study flowchart.

3.1.1 Adsorbent Preparation

The adsorbent used in this study are the wastes generated from the agricultural sector. The oil palm leaves are taken form the oil palm plantation area whereas the corn husks are taken from the local night market. Figure 8 and 9 shows the process flow of the preparation of the adsorbents.

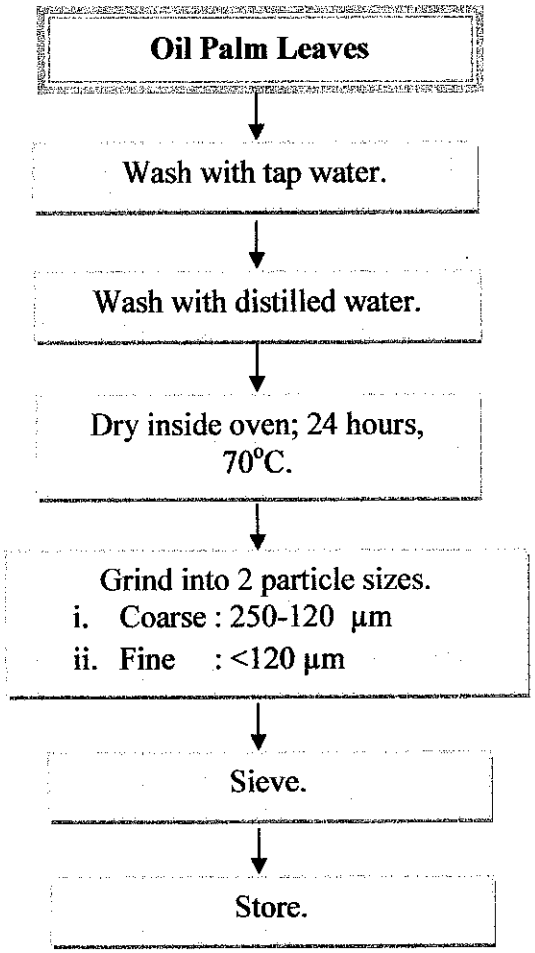


Figure 8: Process flow of adsorbent preparation made from oil palm leaves.

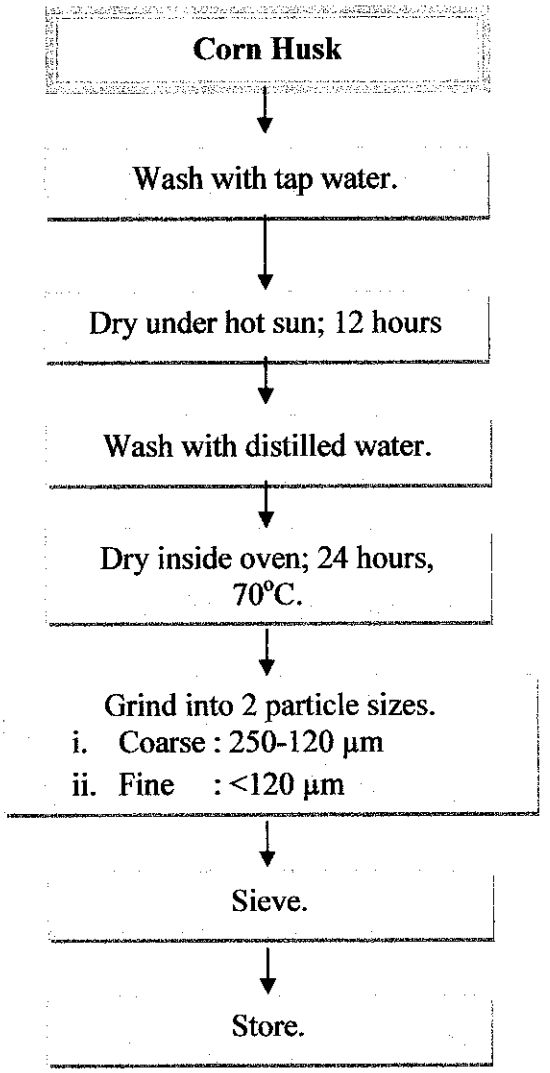
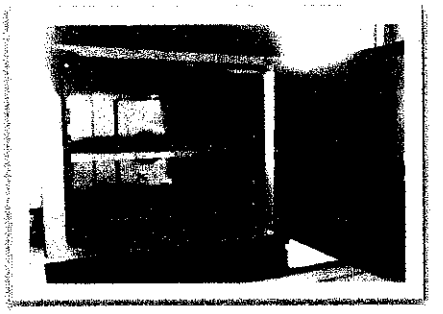


Figure 9: Process flow of adsorbent preparation made from corn husk.

The preparation of oil palm leaves and corn husk as the adsorbents are shown in figure 10 and 11, respectively.

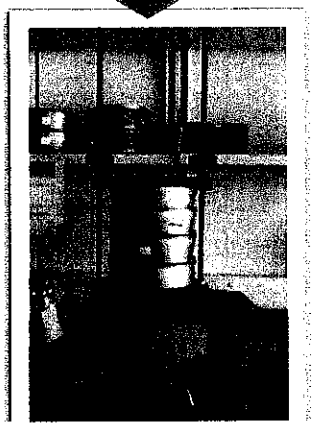
Dried oil palm leaves are taken from the oil palm plantation area.

Oil palm leaves are washed using tap water, continued by distilled water.

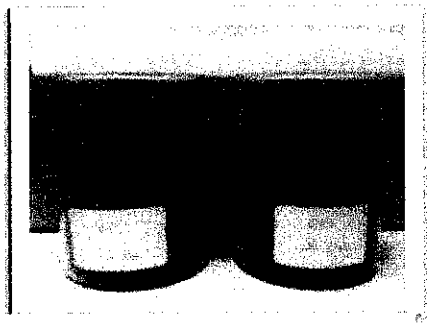


Washed oil palm leaves are dried inside the drying oven at 70°C for 24 hours.

Dried oil palm leaves taken out from the drying oven.

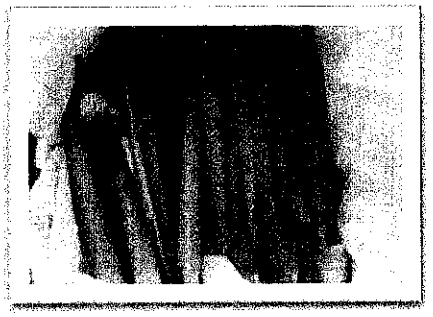


Grinded adsorbent is sieved in obtaining the required particle size.



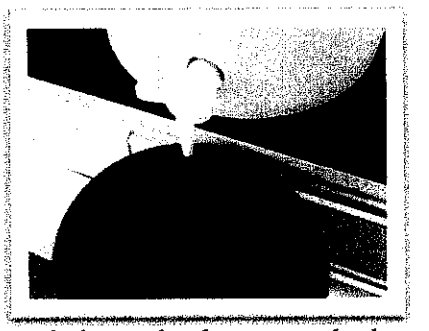
Prepared adsorbent is stored for further use.

Figure 10: Preparation of adsorbent made from oil palm leaves.

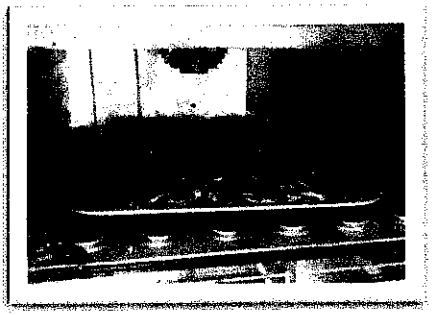


Corn husks are obtained from the night market. It is the waste from a corn stall.

Corn husks are washed with tap water and dried under hot sun for 24 hours.

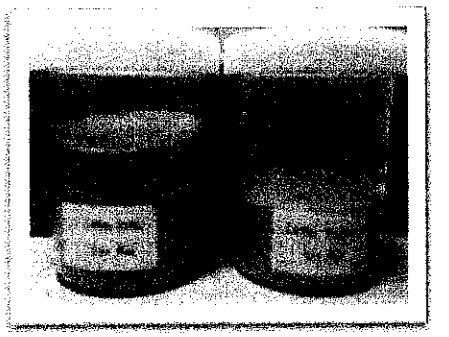


Dried corn husks are washed using distilled water.



Corn husks are further dried inside the drying oven at 70°C for 24 hours.

Grinded adsorbent is sieved in obtaining the required particle size.



Prepared adsorbent is stored for further use.

Figure 11: Preparation of adsorbent made from corn husk.

3.1.2 Adsorbate Preparation.

A. Stock Solution

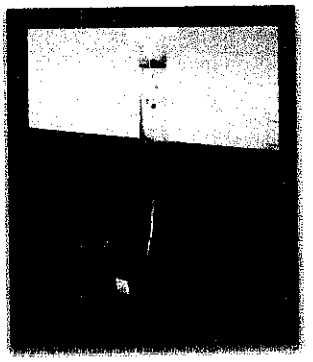


Figure 12: Stock solution of Methylene Blue.

Dye; Methylene Blue is diluted into stock solution of 1000 mg/L. Method below details on how stock solution is prepared.

i. 1000 mg of Methylene Blue powder is weighed into a Petri plate using a weighing machine.
ii. The powder is diluted using distilled water.
iii. The solution is filled into a 1 L volumetric flask and distilled water is added to fulfill the volumetric flask.

Figure 12 shows the stock solution of Methylene Blue.

B. Dye Standard Calibration Curve

Methylene Blue stock solution is further diluted using distilled water to get various concentrations which is from 0 mg/L 10 mg/L as shown in figure 13. Equation is used to obtain the required amount of distilled water needed to make the dilution.

$$M_1 V_1 = M_2 V_2 \quad (1)$$

M = dye concentration, mg/L

V = solution volume, mL

The Methylene Blue standard calibration curve is attached in Appendix 3.

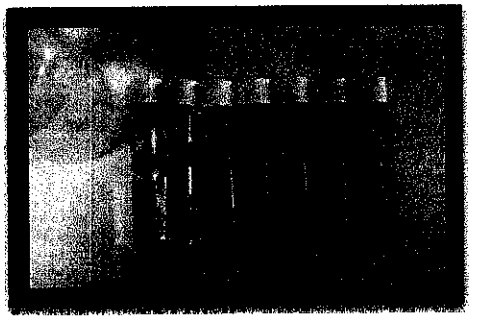


Figure 13: Methylene Blue in various concentrations (0 mg/L – 10.0 mg/L).

3.1.3 Moisture Content Test.

This test is conducted to ensure that there is no water content left inside the adsorbent prepared. Steps below explained how the test is carried out.

i. An empty tray is weighed; W_t.

ii. The adsorbent powder is filled onto a tray. The tray is weighed together with the adsorbent; W_a.

iii. The adsorbent is put inside the oven with the temperature of 100°C.

iv. The tray with adsorbent is weighed at 15 minutes time interval for 1 hours; W_{at}.

v. The equation is used to calculate the initial weight of adsorbent;

$$\textit{Initial weight of adsorbent: } W_t - W_a \tag{2}$$

vi. The equation is used to calculate the weight of adsorbent at the interval time;

$$\textit{Weight of adsorbent at time t: } W_t - W_{at} \tag{3}$$

3.1.4 Adsorption Run.

Batch kinetic experiments are carried out. The conditions of the experiments are as below:

a. Temperature : Ambience temperature.
b. Solution pH : 7-8
c. Initial dye concentration: 50 mg/L

Batch experiments are conducted using 100 mL of bottle at a total sample volume of 50 mL for each adsorption run. The bottle is being agitated in a reciprocating shaker. Samples are withdrawn at suitable time intervals by having them centrifuged for 3 hours. In every 30 minutes of each run, a little portion of every sample is taken and the concentrations are measured using UV/Vis Spectrophotometer.

The adsorption capacity (q) is calculated using the following equation

$$q = \frac{(Co - Ct)V}{m} \tag{4}$$

q = Adsorption capacity.
Co = Initial concentration (mg/L).
Ct = Concentration at time interval, t (mg/L).
V = Volume of solution (L).
m = Adsorbent mass (g).

The dye removal percentage is calculated using the following equation

$$\%removal = \frac{Co - Ct}{Co} \times 100 \tag{5}$$

The following experimental procedures were conducted;

a. **Experiment 1: The effect of adsorbent particle size to adsorption process.**

i. 0.25g of adsorbent (coarse & fine particle size) is weighed using a weighing machine.
ii. Each adsorbent is filled into a 100mL bottle. (Bottle A: Coarse particle; Bottle B: Fine particle)
iii. Bottles are placed onto the shaker.
iv. 50mL of 50mg/L dye solution is pipet and filled into the bottles.
v. Simultaneously, the shaker and stop watch are turned 'ON'. (Shaker speed: 160rpm)
vi. Within every 30 minutes, samples of dye solution in each bottle are taken, filtered and tested using the UV/Vis Spectrophotometer.
vii. Data for Ct (Concentration at time interval, mg/L) is recorded.
viii. Dye concentration, adsorption capacity, q and removal percentage, (%) for each time interval are calculated and plot into a graph.

b. **Experiment 2: The effect of adsorbent mass to adsorption process.**

i. Adsorbent is weighed into 0.15g, 0.40g, 0.80g and 1.00g using a weighing machine. (Optimum particle size from experiment A is used.)
ii. Each adsorbent is filled into a 100mL bottle.

Bottle A: 0.15g
B: 0.40g
C: 0.80g
D: 1.00g

iii. Bottles are placed onto the shaker.
iv. 50mL of 50mg/L dye solution is pipet and filled into each of the bottles.
v. Simultaneously, the shaker and stop watch are turned 'ON'. (Shaker speed: 160rpm)

vi. Within every 30 minutes, samples of dye solution in each bottle are taken, filtered and tested using the UV/Vis Spectrophotometer.

vii. Data for Ct (Concentration at time interval, mg/L) is recorded.

viii. Dye concentration, adsorption capacity, q and removal percentage, (%) for each time interval are calculated and plot into a graph.

c. **Experiment 3: The effect of dye initial concentration to adsorption process.**

i. Dye stock solution (400mg/L) is diluted with distilled water into the concentration of 200 mg/L, 100 mg/L, and 50 mg/L. (Equation: $M_1 V_1 = M_2 V_2$)

ii. Adsorbent is weigh using a weighing machine. (Optimum particle size from experiment A & optimum mass from experiment B is used.)

iii. Adsorbent with same particle size and mass is filled into the bottles.

iv. Bottles are placed onto the shaker.

v. 50mL of each dye concentration including the stock solution is pipet and filled into the conical flasks.

Bottle A: 400mg/L
B: 200mg/L
C: 100mg/L
D: 50mg/L

vi. Simultaneously, the shaker and stop watch are turned 'ON'. (Shaker speed: 160rpm)

vii. Within every 30 minutes, samples of dye solution in each bottle are taken, filtered and tested using the UV/Vis Spectrophotometer.

viii. Data for Ct (Concentration at time interval, mg/L) is recorded.

ix. Dye concentration, adsorption capacity, q and removal percentage, (%) for each time interval are calculated and plot into a graph.

3.2 Experiment Matrix

Adsorbent: 1. Oil Leaves 2. Corn Husk

Experiment:

1. Effect of adsorbent particle size to the adsorption capacity.
2. Effect of the mass of adsorbent to the adsorption capacity.
3. Effect of the initial dye concentration to the adsorption capacity.

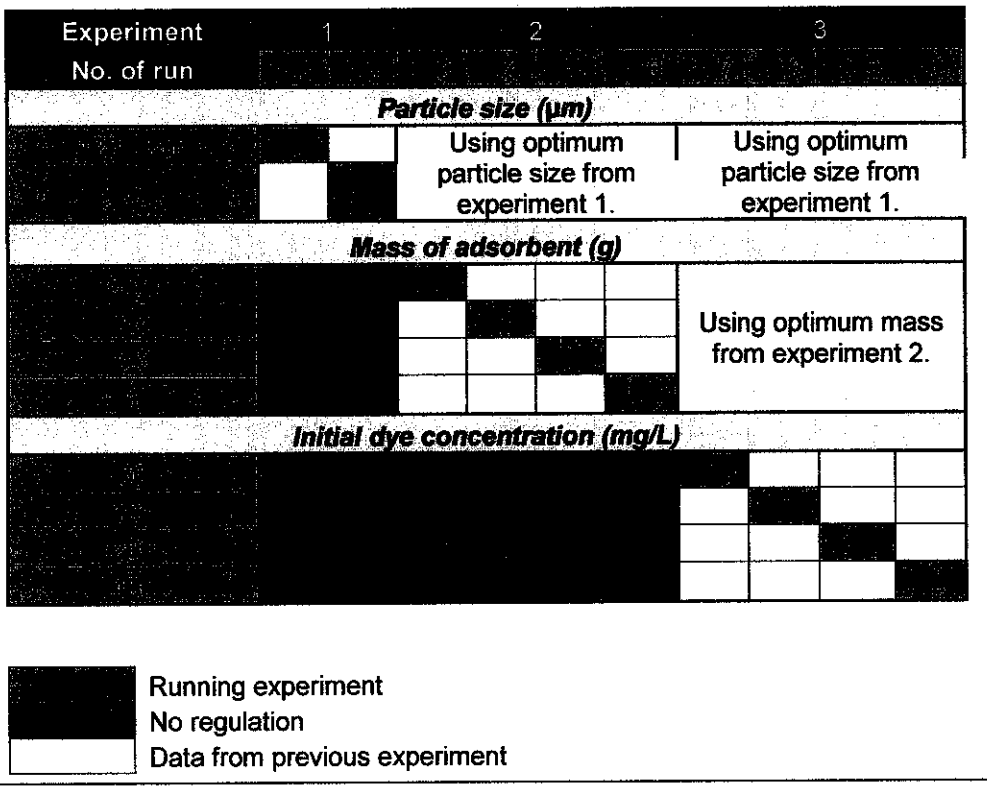


Figure 14: Experiment Matrix of Research Study.

3.3 Key Milestone.

The key milestone of the research study is attached in Appendix 2.

CHAPTER 4

RESULT & DISCUSSION

4.1 Research Findings.

4.1.1 Moisture Content Test.

This test is done to make sure both adsorbent are fully dried. Results of <10% of water content contain in the prepared adsorbent is highly desired. At this level, microorganisms are not active (Geankopolis, 2003). Table 6 and 7and figure 15 and 16 show the results of the test for both adsorbents.

a. Adsorbent: Oil palm leaf

Table 6: Oil palm leave's weight for 1 hour test.

Adsorbent Weight (g)	Time (min)
36.6	0
36.3	15
36.3	30
36.3	45
36.3	60

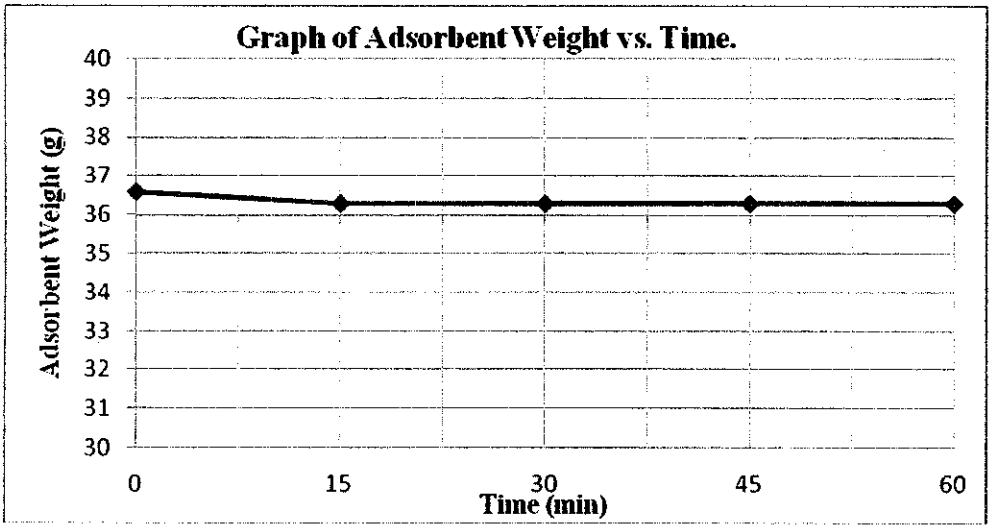


Figure 15: Graph for moisture content test of oil palm leaves.

b. Adsorbent: Corn Husk

Table 7: Corn husk's weight for 1 hour test.

Adsorbent Weight (g)	Time (min)
36.6	0
36.5	15
36.5	30
36.5	45
36.5	60

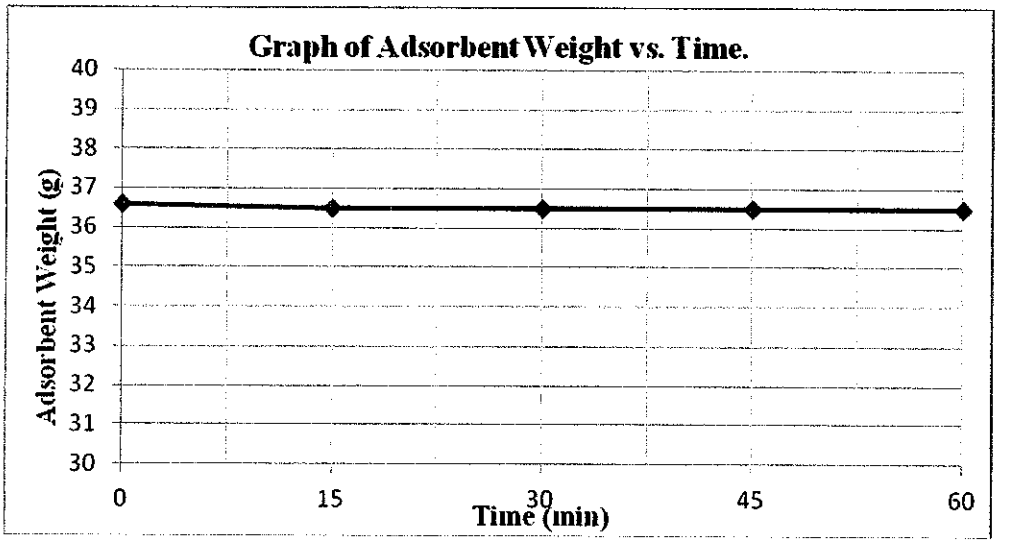


Figure 16: Graph of adsorbent weight vs. time for corn husk.

Referring to both of the graphs, it shows that there is minor change in weight for both of the adsorbent; oil palm leaf and corn husk.

Weight (%) calculation;

$$\frac{W_1 - W_2}{W_1} \times 100$$

For oil palm leaf,

$W_1 = 36.6$ g $\quad W_2 = 36.3$ g

$$\frac{36.6-36.3}{36.6}\times 100 = 0.8197\%$$

For corn husk,

$W_1 = 36.6$ g $\quad W_2 = 36.5$ g

$$\frac{36.6-36.5}{36.6}\times 100 = 0.2732\%$$

From the data obtained and calculation done, it shows that the moisture content in both adsorbent is <1%. It is proven that both adsorbent are fully dried during the preparation time.

4.1.2 Adsorption Using Oil Palm Leaves and Corn Husk.

4.1.2.1 The effect of adsorbent particle size to the adsorption process.

Table 8 and figure 17, 18 and 19 show the result of dye concentration remain in test solution, adsorption capacity and percentage removal on the effect of oil palm leaves with different particle size, respectively.

Table 8: Result on the effect of oil palm leaves particle size to the adsorption of Methylene Blue.

Time (min)	Dye concentration at time t (C_t, mg/L)		Adsorption capacity at time t (q_t, mg/g)		% removal at time t (%)	
	125µm	250µm	125µm	250µm	125µm	250µm
0	50	50	0	0	0	0
30	1.973	2.971	9.605	9.406	96.054	94.058

60	1.542	1.930	9.692	9.614	96.916	96.14
90	1.409	1.649	9.718	9.670	97.182	96.702
120	1.405	1.583	9.719	9.683	97.19	96.834
150	1.208	1.495	9.758	9.701	97.584	97.010
180	1.396	1.497	9.721	9.701	97.208	97.006

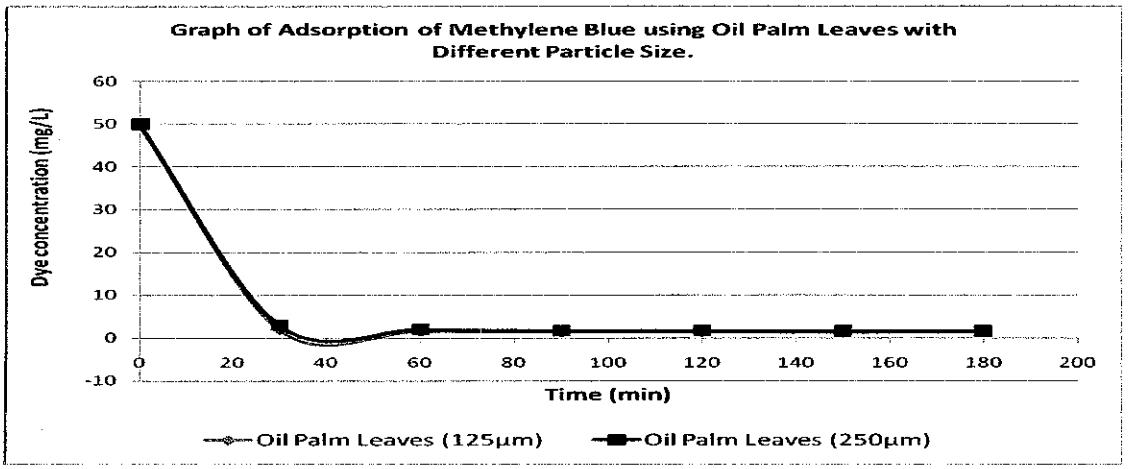


Figure 17: Result on dye concentration remain in test solution on the adsorption using different adsorbent particle size.

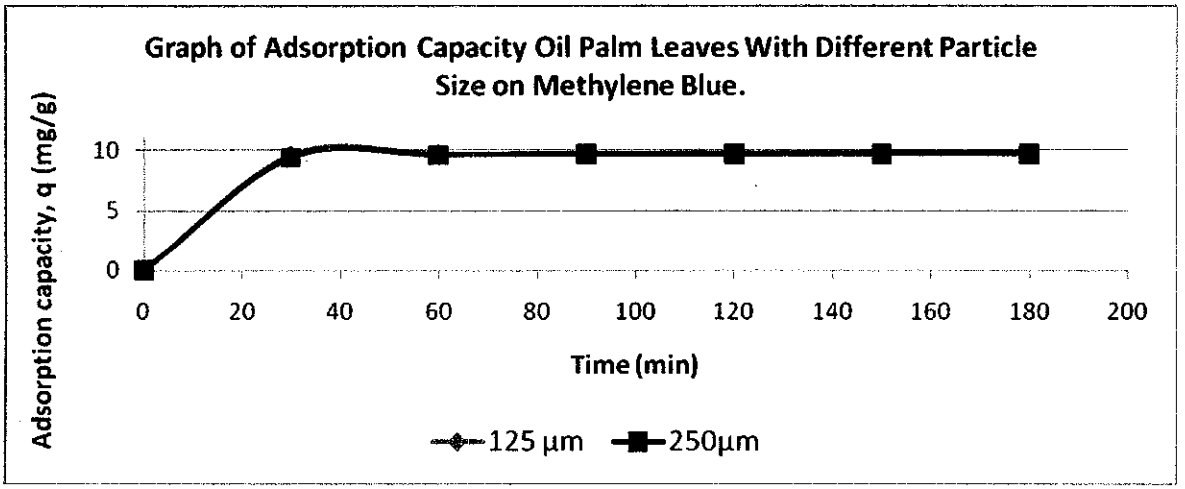


Figure 18: Result on adsorption capacity on the adsorption using different adsorbent particle size.

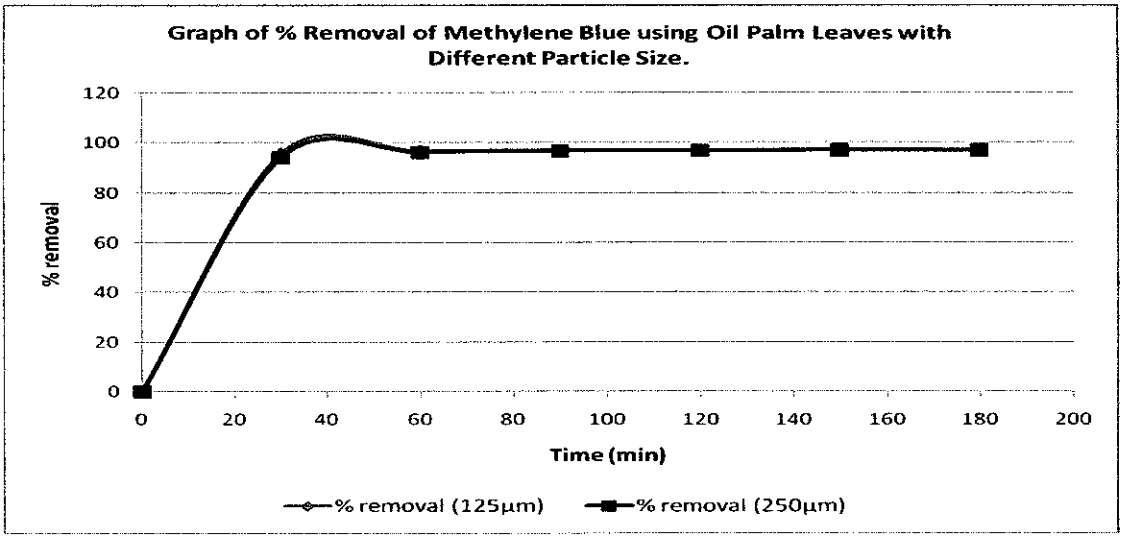


Figure 19: Result on percentage removal on the adsorption using different adsorbent particle size.

Table 9 and figure 20, 21 and 22 show the result of dye concentration remain in test solution, adsorption capacity and percentage removal on the effect of corn husk with different particle size, respectively.

Table 9: Result on the effect of corn husk particle size to the adsorption of Methylene Blue.

Time (min)	Dye concentration at time t (C_t), mg/L		Adsorption capacity at time t (q_t), mg/g		% removal at time t (%)	
	125µm	250µm	125µm	250µm	125µm	250µm
0	50	50	0	0	0	0
30	1.404	1.830	9.719	9.634	97.192	96.340
60	1.402	1.573	9.720	9.685	97.196	96.854
90	1.343	1.384	9.731	9.723	97.314	97.232
120	1.135	1.297	9.773	9.741	97.730	97.406
150	1.267	1.315	9.747	9.737	97.466	97.370

180	1.269	1.468	9.746	9.706	97.466	97.064

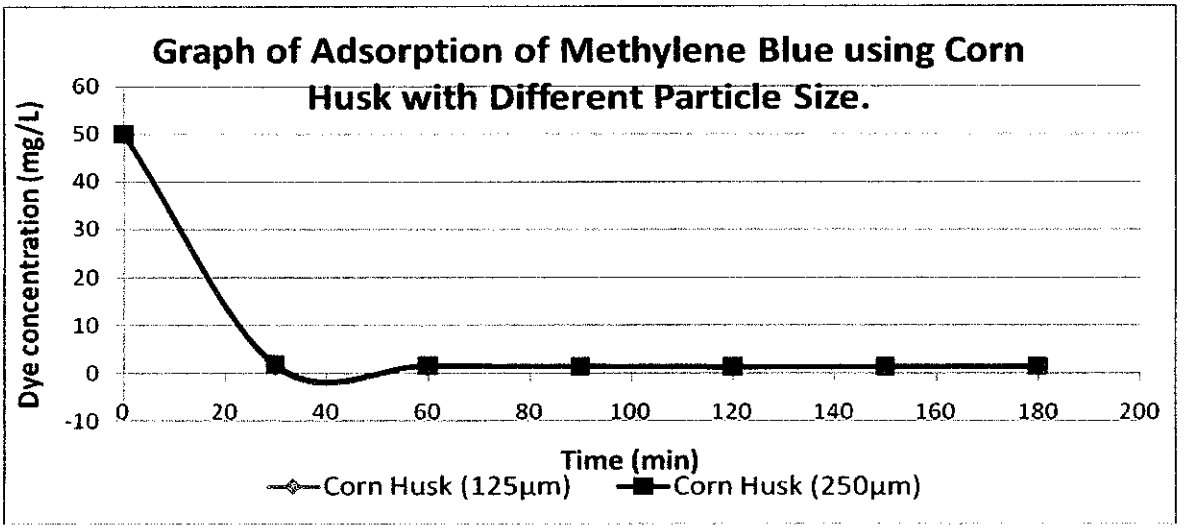


Figure 20: Result on dye concentration remain in test solution on the adsorption using different adsorbent particle size.

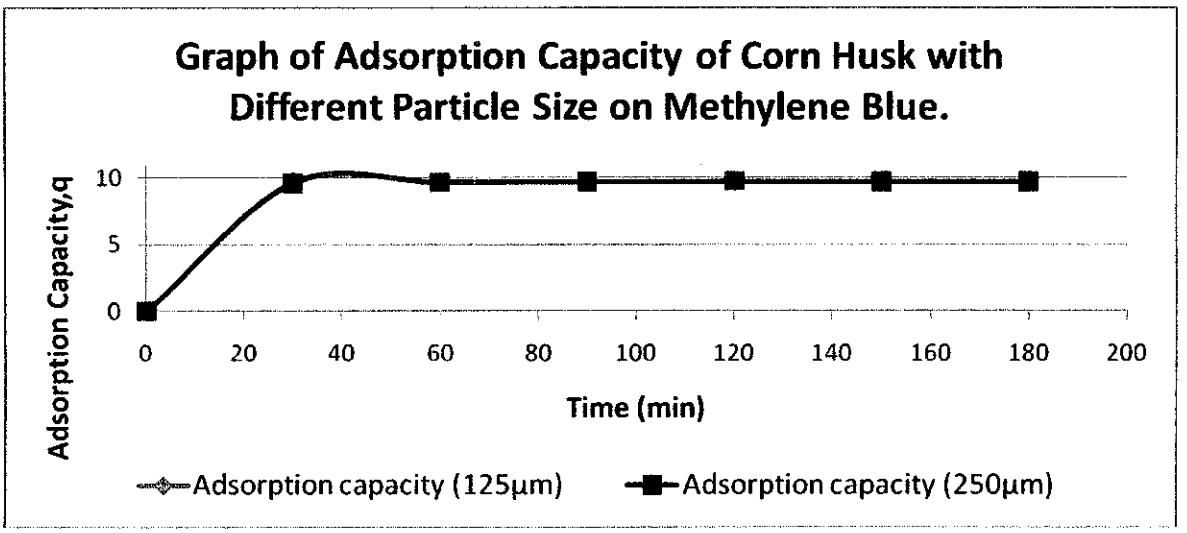


Figure 21: Result on adsorption capacity on the adsorption using different adsorbent particle size.

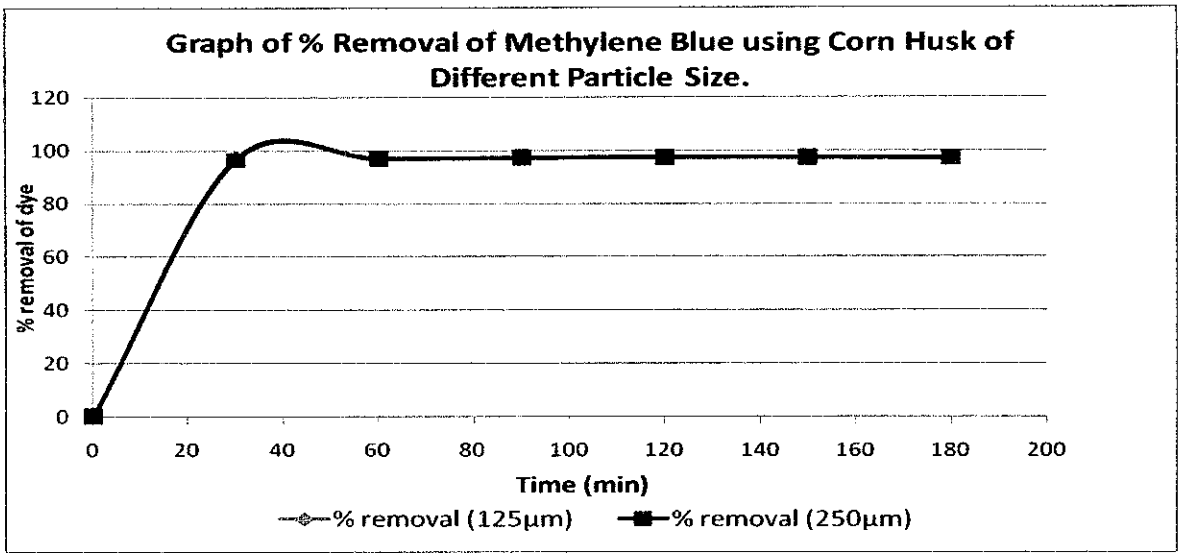


Figure 22: Result on percentage removal on the adsorption using different adsorbent particle size.

The effect of particle size of 125µm and 250µm on the adsorption process using oil palm leaves and corn husk was studied with test solution volume of 50 mL, dye initial concentration of 50 mg/L and adsorbent mass of 0.25g. From the results (refer to figure 17,18,19,20,21 & 22), indicate that the range of adsorbent particle size chosen does not show significance effect to be compared. Anyway, the smaller particle size which is 125µm managed to removed slightly higher amount of dye from the solution for both oil palm leaves and corn husk.

For oil palm leaves, when it is compared between 250µm and 125µm particle size, the final dye concentration decreased from 1.497 mg/L to 1.396 mg/L (refer figure 17), the adsorption capacity increased from 9.701 mg/g to 9.721 mg/g (refer figure 18) and the percentage removal increased from 97.006% to 97.208% (refer figure 19) at 180 minutes of contact time. Similarly for corn husk, the final dye concentration decreased from 1.468 mg/L to 1.269 mg/L (refer figure 20), the adsorption capacity increased from

9.706 mg/g to 9.746 mg/g (refer figure 21) and the percentage removal increased from 97.064 % to 97.466 % (refer figure 22).

Smaller particle size has managed to adsorb the dye even more that the larger particle size. This shown by the reduction of the dye concentration. Futhermore, the adsorption capacity,q increased when the adsorbent particle size decreased. Similarly happened for the percentage removal of dye from the solution. The smaller molecular size provide larger space to be in contact compared to bigger molecular size. This resulting to a higher surface area to be in contact with the solution in order to remove the dye. High percentage of dye was managed to be removed within 30 minutes of contact time.

As for that, the 125µm particle size adsorbent will be futher used to observe the effect of adsorbent mass and dye initial concentration on the adsorption of Methylene Blue.

4.1.2.2 The effect of adsorbent mass to the adsorption process.

Table 10 and figure 23, 24 and 25 show the result of dye concentration remain in test solution, adsorption capacity and percentage removal on the effect of adsorbent (oil palm leaves) mass, respectively.

Table 10: Result on the effect of adsorbent (oil palm leaves) mass to the adsorption of Methylene Blue.

Adsorbent mass (g)		0.40		1.00
Time (min)	Dye concentration at time t (C$_t$), mg/L			
0	50	50	50	50
30	4.946	2.223	1.605	1.66
60	1.548	1.417	1.405	1.586
90	1.122	1.398	1.464	1.208
120	1.165	1.236	1.334	1.322
150	1.063	1.145	1.18	1.214

180	0.963	1.284	1.321	1.166
Adsorption capacity at time t (q_t), mg/g				
0	0	0	0	0
30	15.018	5.972	3.025	2.417
60	16.151	6.073	3.037	2.421
90	16.293	6.075	3.034	2.440
120	16.278	6.096	3.042	2.434
150	16.312	6.107	3.051	2.440
180	16.346	6.090	3.042	2.442
% removal at time t (%)				
0	0	0	0	0
30	90.108	95.554	96.79	96.680
60	96.904	97.166	97.19	96.828
90	97.756	97.204	97.072	97.584
120	97.67	97.528	97.332	97.356
150	97.874	97.710	97.64	97.572
180	98.074	97.432	97.358	97.668

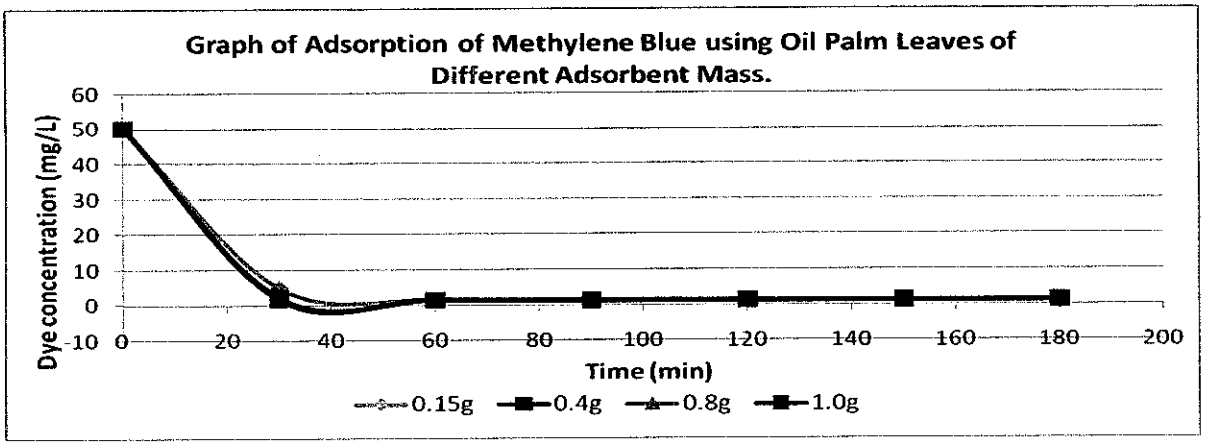


Figure 23: Result on dye concentration remain in test solution on the adsorption using different adsorbent mass.

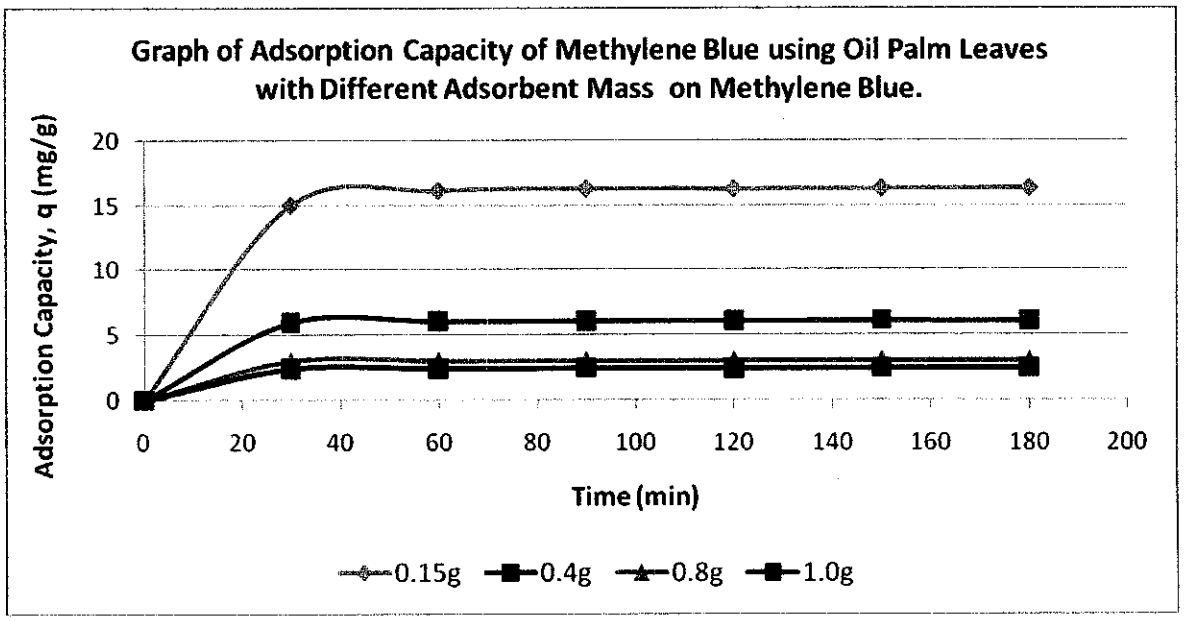


Figure 24: Result on adsorption capacity on the adsorption using different adsorbent mass.

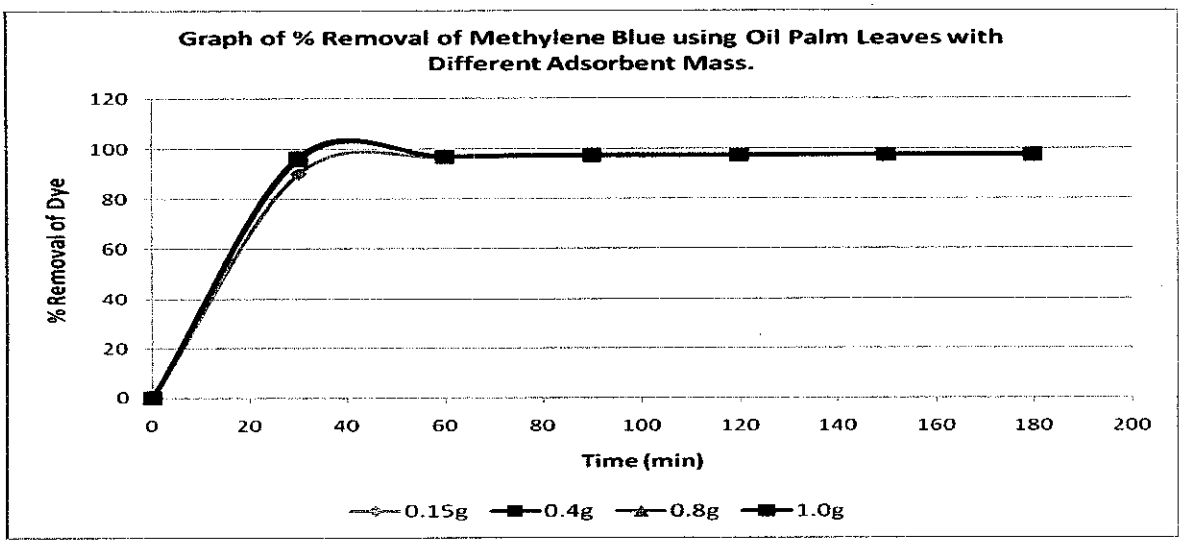


Figure 25: Result on percentage removal on the adsorption using different adsorbent mass.

Table 11 and figure 26, 27 and 28 show the result of dye concentration remain in test solution, adsorption capacity and percentage removal on the effect of adsorbent (corn husk) mass, respectively.

Table 11: Result on the effect of adsorbent (corn husk) mass to the adsorption of Methylene Blue.

Adsorbent mass (g)		0.40		1.00
Time (min)	Dye concentration at time t (C_t), mg/L			
0	50	50	50	50
30	2.500	1.345	1.300	1.270
60	1.452	1.094	1.086	1.076
90	1.474	0.986	0.888	0.867
120	1.434	1.104	1.200	1.100
150	1.227	1.325	1.300	1.250
180	1.045	1.016	1.015	1.017
Adsorption capacity at time t (q_t), mg/g				
0	0	0	0	0
30	15.833	6.082	3.044	2.437
60	16.183	6.113	3.057	2.446
90	16.175	6.127	3.070	2.457
120	16.189	6.112	3.050	2.445
150	16.258	6.084	3.044	2.438
180	16.318	6.123	3.062	2.449
% removal at time t (%)				
0	0	0	0	0
30	95.000	97.310	97.400	97.460

60	97.096	97.812	97.828	97.848
90	97.052	97.028	97.224	98.266
120	97.132	97.792	97.600	97.800
150	97.546	97.350	97.400	97.500
180	97.910	97.968	97.970	97.966

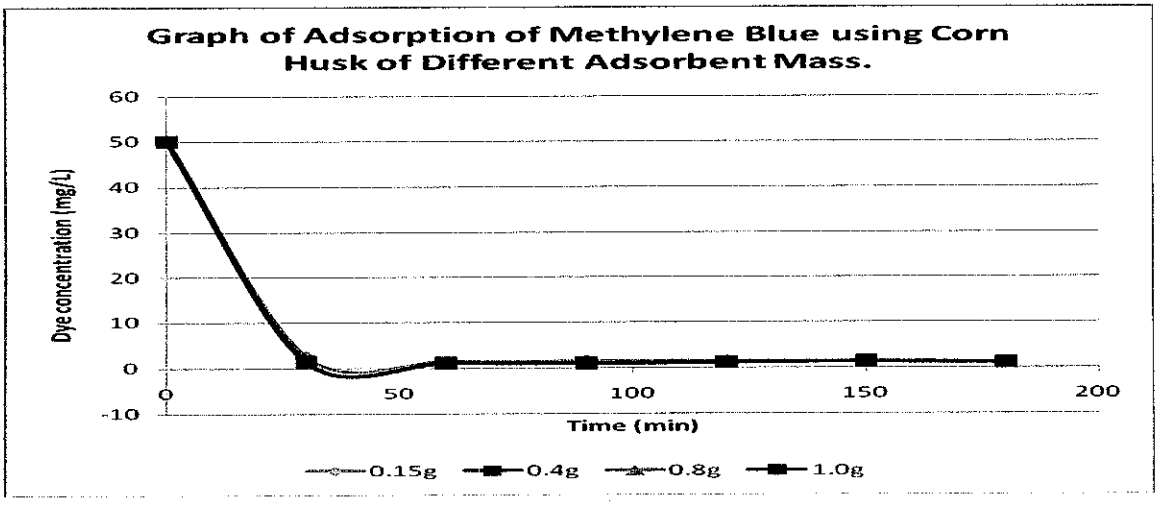


Figure 26: Result on dye concentration remain in test solution on the adsorption using different adsorbent mass.

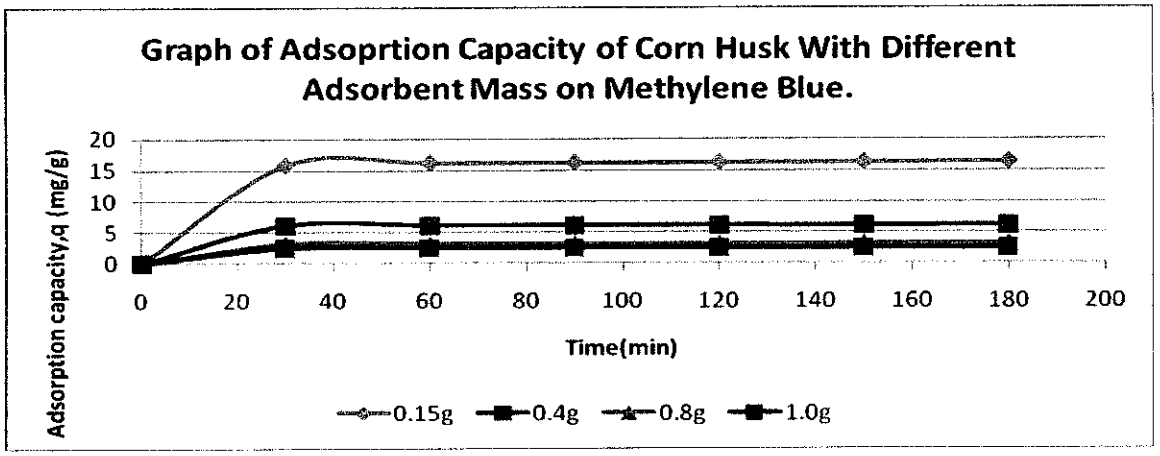


Figure 27: Result on adsorption capacity on the adsorption using different adsorbent mass.

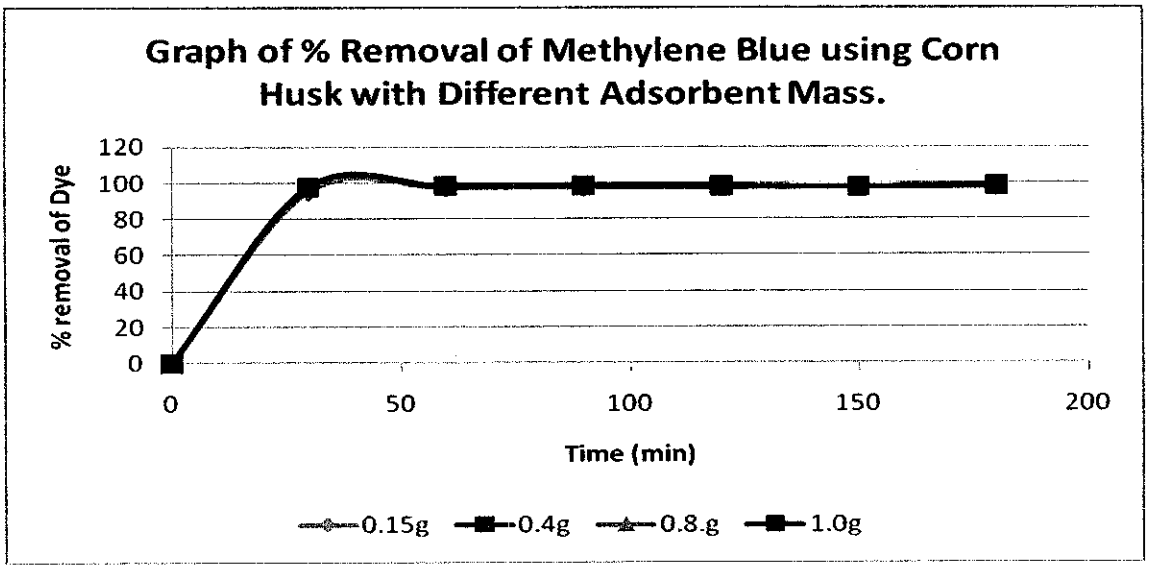


Figure 28: Result on percentage removal on the adsorption using different adsorbent mass.

Four adsorbent mass (0.15g, 0.40g, 0.80g and 1.00 g) which having particle size of 125μm have been evaluated inside the 50 mL test solution while keeping the dye initial concentration at 50mg/L at different contact times for 180 minutes. This is done similarly for oil palm leaves and corn husk. For both adsorbent, the maximum dye removal was achieved within 30 – 40 minutes after which the concentration of dye inside the solution was almost constant.

As for oil palm leaves, the adsorption capacity decreased from 16.346 mg/g to 2.442 mg/g as the adsorbent mass increased from 0.15g to 1.00g / 50mL in the test solution (refer figure 24). Moreover, for corn husk, when the adsorbent mass is increased from 0.15g to 1.00g / 50mL in the test solution, the adsorption capacity decreased from 16.318 mg/g to 2.449 mg/g (refer figure 27). For oil palm leaves, the highest percentage of dye removal is 98.074% (refer table 10) is achieved at T = 180 minutes for adsorbent mass = 0.15g whereas for corn husk, the highest percentage of dye removal is 97.968% (refer table 11) is achieved at T = 180 minutes for adsorbent mass = 0.40 g.

Higher amount of mass will have higher percentage removal of dye as it provides more adsorption sites with high surface area to adsorb the dye inside the solution. The decrease in the adsorption capacity happened due to the overlapping of adsorption sites.

Garg, et al (2004) supported this with the statement that increased in the adsorption with adsorbent dose can be attributed to increased surface area and availability of more adsorption sites. The decreased of adsorption capacity, q happen due to the overlapping or aggregation of adsorbent sites resulting on the decrease in total surface area available to adsorb dye.

Anyway, the range of adsorbent mass used for the evaluation of both adsorbent does not really showed significance effect. This is the reason why the range of dye concentration after adsorption is done and the percentage removal of dye by both adsorbents are closed enough within each other. In continuing to the next experiment, the optimum mass chosen for oil palm leaves and corn husk is 0.40g.

For oil palm leaves, even though adsorbent mass of 0.15 g gives the highest percentage removal of dye compared to 0.40 g but the reaction time of adsorbent mass 0.15g is lower compared to 0.40g. At T = 30 minutes, dye concentration inside the test solution for 0.15 g is 4.946 mg/L whereas for 0.40g is already 2.223 mg/L. For corn husk, when compared between 0.40g, 0.80g and 1.0g, the values of dye concentration remain in the test solution and the percentage removal of dye are too closed with the difference of 0.002. As for that, the lowest adsorbent mass is chosen.

4.1.2.3 The effect of initial dye concentration to the adsorption process.

Table 12 and figure 29, 30 and 31 show the result of dye concentration remain in the test solution, adsorption capacity and percentage removal on the effect of initial dye concentration for oil palm leaves as the adsorbent, respectively.

Table 12: Result on the effect of dye initial concentration to the adsorption.

Dye initial concentration (mg/L)	100	400
Time (min)	Dye concentration at time t (C), mg/L	

0	50	100	200	400
30	1.857	2.402	5.228	6.546
60	1.624	2.363	4.971	9.24
90	1.755	2.572	3.822	9.283
120	1.837	2.591	4.217	5.317
150	1.426	2.275	3.618	5.955
180	1.557	2.385	2.997	4.993
Adsorption capacity at time t (q_t), mg/g				
0	0	0	0	0
30	6.018	12.200	24.347	49.182
60	6.047	12.205	24.379	48.845
90	6.031	12.179	24.522	48.840
120	6.020	12.176	24.473	49.335
150	6.072	12.217	24.548	49.256
180	6.055	12.202	24.625	49.276
0	0	0	0	0
30	96.286	97.598	97.386	98.364
60	96.752	97.637	97.515	97.690
90	96.490	97.428	98.089	97.679
120	96.326	97.409	97.892	98.671
150	97.148	97.725	98.191	98.511
180	96.886	97.615	98.502	98.752

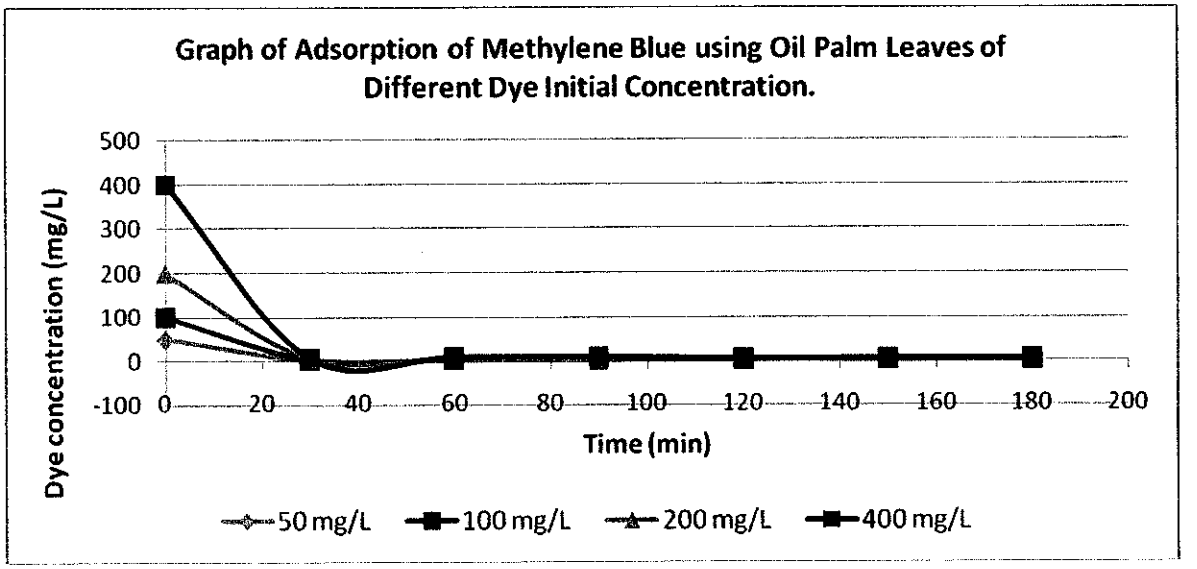


Figure 29: Result on dye concentration remain in test solution on the adsorption using different dye initial concentration.

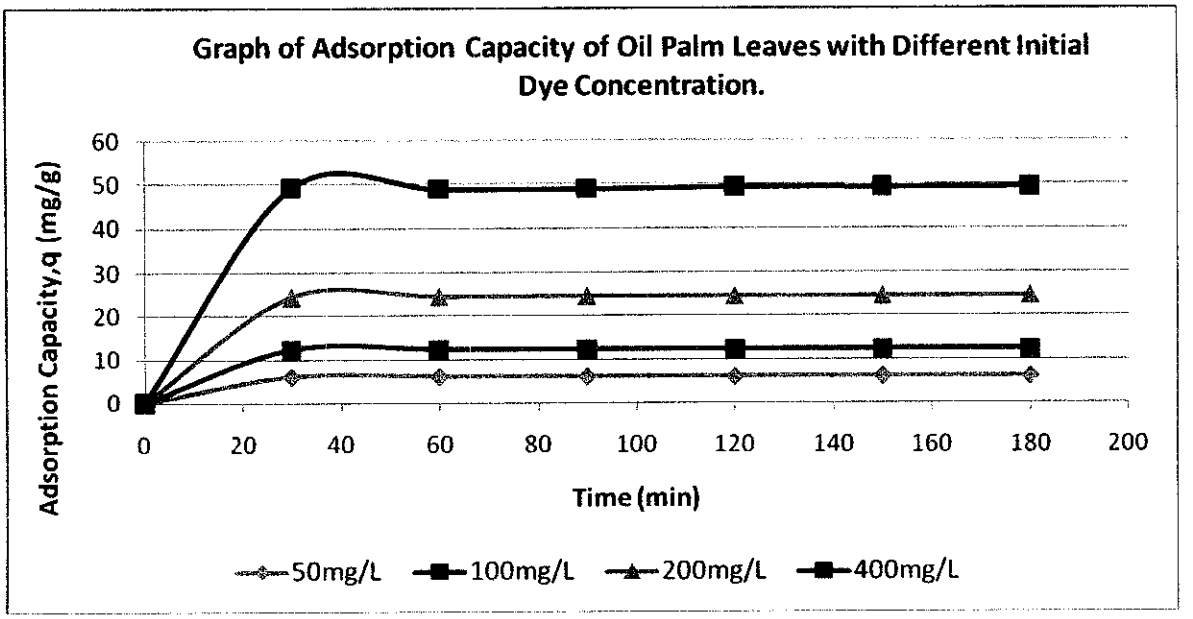


Figure 30: Result on adsorption capacity on the adsorption using different dye initial concentration.

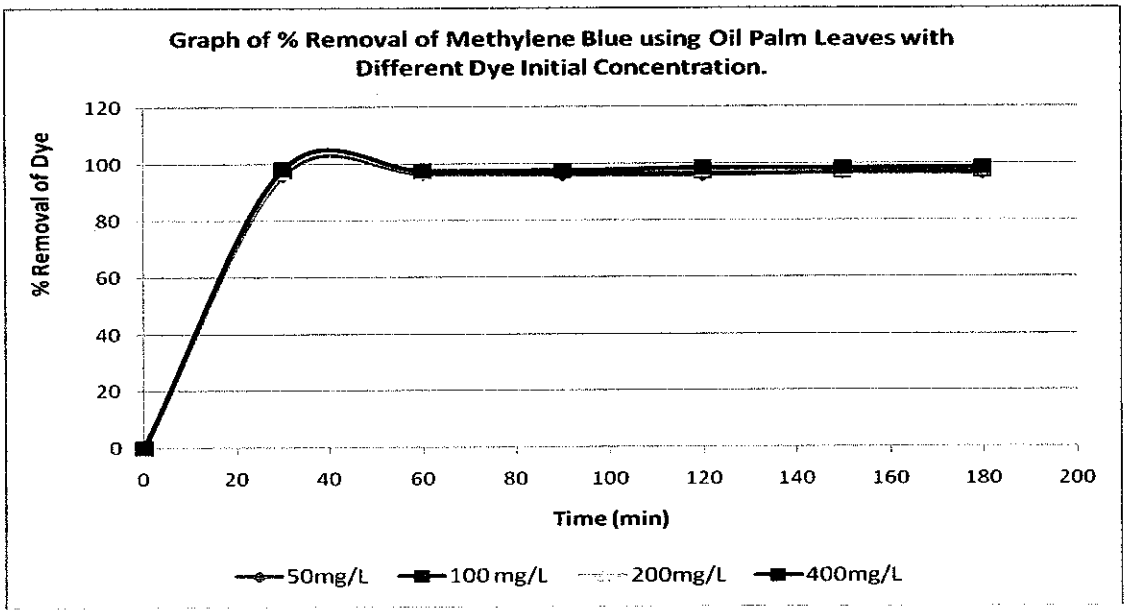


Figure 31: Result on % removal on the adsorption using different dye initial concentration.

Table 13 and figure 32, 33 and 34 show the result of dye concentration remain in test solution, adsorption capacity and percentage removal on the effect of initial dye concentration for corn husk as the adsorbent, respectively.

Table 13: Result on the effect of dye initial concentration to the adsorption.

Dye initial concentration (mg/L)	50	100	200	400
Time (min)	Dye concentration at time t (C_t), mg/L			
0	50	100	200	400

30	1.345	1.888	3.229	5.647
60	1.094	1.768	3.123	5.213
90	0.986	1.657	3.006	4.987
120	1.104	1.712	3.356	4.887
150	1.325	1.734	3.987	4.987
180	1.016	1.678	3.213	4.768
Adsorption capacity at time t (q_t), mg/g				
0	0	0	0	0
30	6.082	12.264	24.596	49.294
60	6.113	12.279	24.610	49.348
90	6.127	12.293	24.624	49.377
120	6.112	12.286	24.581	49.389
150	6.084	12.283	24.502	49.377
180	6.123	12.290	24.598	49.404
0	0	0	0	0
30	97.310	98.112	98.386	98.588
60	97.812	98.232	98.439	98.697
90	98.028	98.343	98.497	98.753
120	97.792	98.288	98.322	98.778
150	97.350	98.266	98.007	98.753
180	97.968	98.322	98.394	98.808

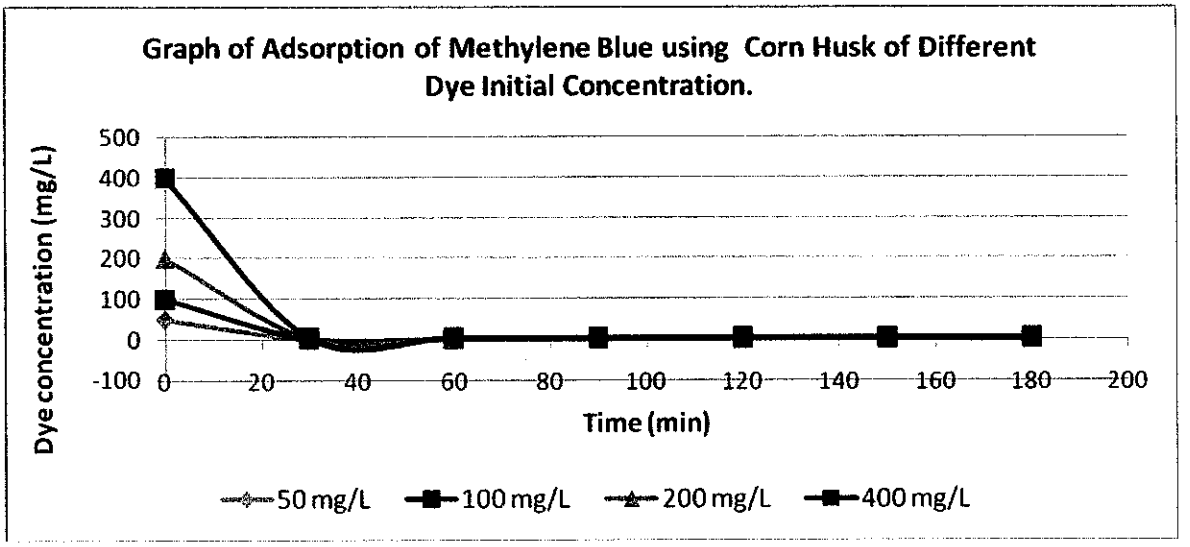


Figure 32: Result on dye concentration remain in test solution on the adsorption using different dye initial concentration.

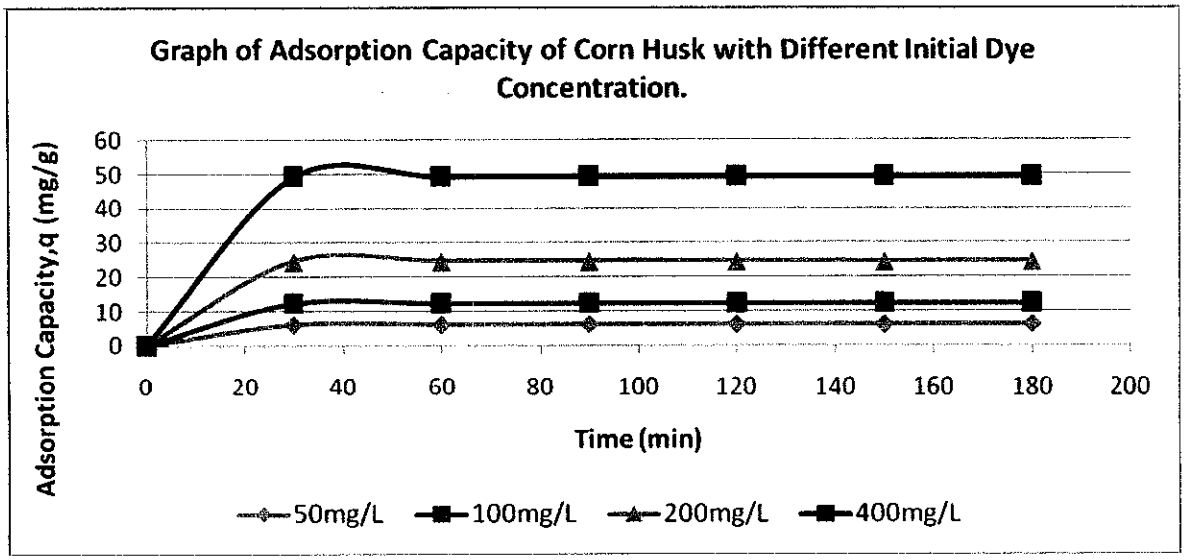


Figure 33: Result on adsorption capacity on the adsorption using different dye initial concentration.

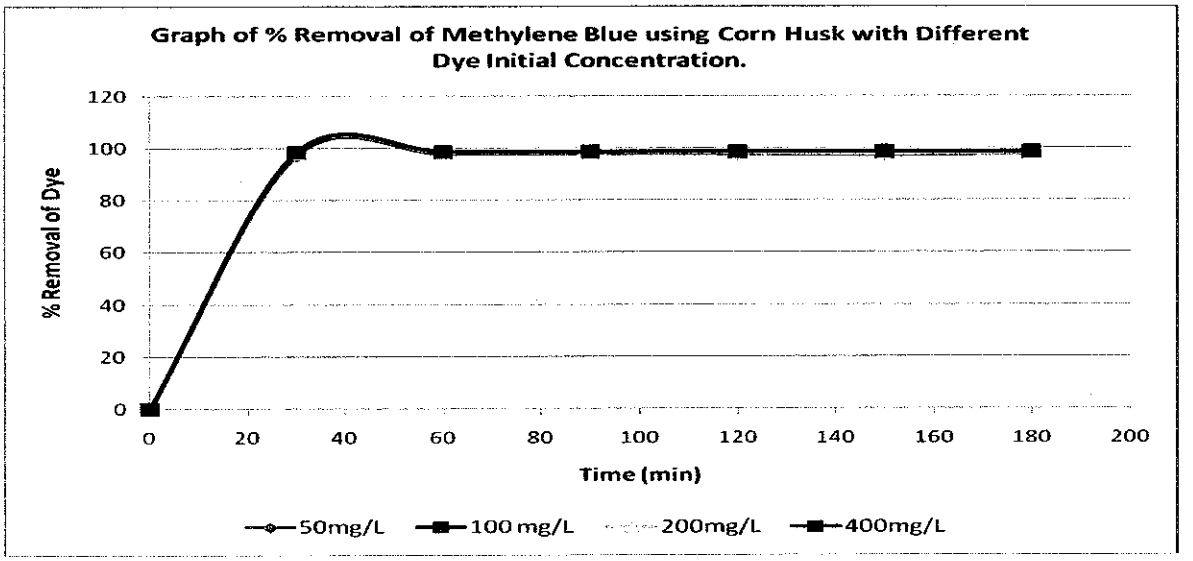


Figure 34: Result on percentage removal on the adsorption using different dye initial concentration.

The effect of dye initial concentration was tested using optimum adsorbent particle size of 125µm and optimum adsorbent mass of 0.40 g while the test solution was remained at volume of 50 mL for adsorbent, oil palm leaves and corn husk. Within 30 – 40 minutes of contact time, the dye has been further removed. It can be seen that, the adsorption capacity, q and the percentage removal increased as the dye initial concentration increased.

For oil palm leaves, the adsorption capacity, q increased from 6.055 mg/g to 49.276 mg/g (refer figure 30) and the percentage removal of dye increased from 96.886% to 98.752% (refer figure 31) as the dye initial concentration increased from 50 mg/L to 400 mg / L. Besides that, for corn husk similar result is obtained. The adsorption capacity, q increased from 6.123 mg/g to 49.404 mg/g (refer figure 33) while the percentage removal of dye increased from 97.968% to 98.808% (refer figure 34).

These phenomena happened due to the concentration that provides an important driving force for the dye to overcome all mass transfer resistance between the aqueous and solid phases. Higher amount of dye ions are present within the same amount of adsorbent sites when the concentration is higher .That is why, higher adsorbate managed to be adsorb. These supported by the finding by B.H Hameed et al, (2008) that stated a

higher initial concentration of dye will enhance the adsorption process. Han et al (2007) mention that if the concentration of MB in the solution was bigger, the active sites of adsorbates were surround by much more MB ions that the process of adsorption would carry out more sufficient.

From the experiments done for adsorbent prepared from oil palm leaves and corn husk, it was obtained that;

i. smaller particle size (125μm),
ii. higher adsorbent mass (0.40g) and
iii. higher dye initial concentration (400 mg/L);

will effectively increased the efficiency of the adsorption process.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 Relevancy of Objectives.

In conclusion, the result revealed that the proposed adsorbents which are oil palm leaves and corn husk have the potential to remove dye (Methylene Blue). The findings on the effect of adsorbent particle size, adsorbent mass and dye initial concentration on the adsorption process are according the exact theory. Adsorption increased by having smaller particle size, higher adsorbent mass and higher dye initial concentration. The abundant agricultural wastes available should not be thrown but it can be use or recycle to be the potential low cost adsorbent compared to activated carbon. The simplicity of the adsorbent preparation compared to the preparation of activated carbon has been a reason to use this agricultural waste as an adsorbent. The agricultural waste can be fully utilized rather than dumping it straight away to the landfill.

5.2 Recommendations & Future Work.

Below are the suggested ways for the expansion and continuation of this research study;

i. Bigger range of the parameter chosen in order to compared the effect of adsorption between each other.

ii. To used the real wastewater sample from the industries to see the efficiency of the natural sorbent in removing dye.

As to commercialize the uses of proposed adsorbent in the industries, the adsorbent shall be used in a granule form or to be made into a filter cloth in order to be used in one level of treatment at the wastewater treatment plant.

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APPENDICES

Appendix 1: Final Year Project I & II Planning Schedule

Appendix 2: Key milestone of research study.

Appendix 3: Dye Standard Calibration Curve

Appendix 1-Final Year Project I & II Planning Schedule

Final Year Project 1
REMOVAL OF DYE IN WASTEWATER VIA ADSORPTION USING AGRICULTURAL WASTE (NATURAL SORBENT)
PLANNING SCHEDULE

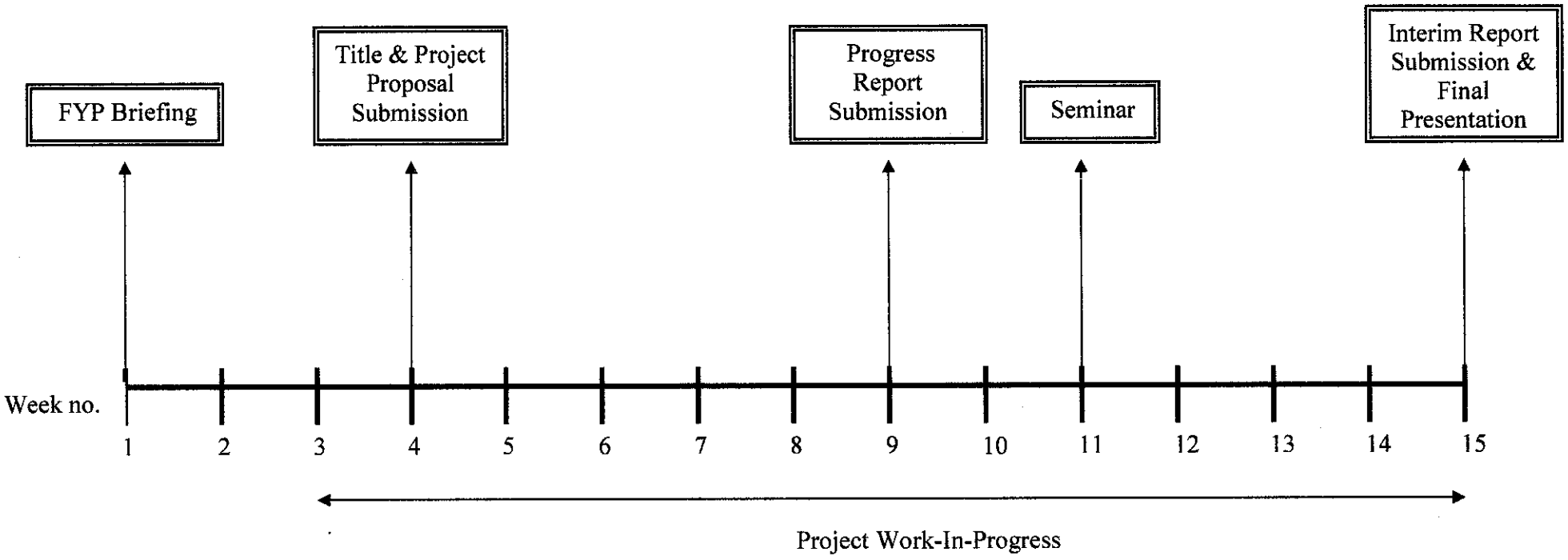
	WEEK NUMBER																
	1 JULY - 7 JULY	8 JULY - 14 JULY	15 JULY - 21 JULY	22 JULY - 28 JULY	29 JULY - 4 AUG	5 AUG - 11 AUG	12 AUG - 18 AUG	19 AUG - 25 AUG	26 AUG - 1 SEPT	2 SEPT - 8 SEPT	9 SEPT - 15 SEPT	16 SEPT - 22 SEPT	23 SEPT - 29 SEPT	30 SEPT - 6 OCT	7 OCT - 13 OCT	14 OCT - 20 OCT	21 OCT - 27 OCT	28 OCT - 3 NOV	4 NOV - 10 NOV
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Paper Work submission																Study Week	Final Examination
1. Tittle & Project proposal.																	
2. Preliminary Report.																	
3. Progress Report.																	
4. Interim Report.																	
Briefing & Seminar																	
1. FYP briefing.																	
2. Seminar: Research Methodology.																	
3. "Library facilities & how to access journals" briefing.																	
4. Seminar 1																	
5. "Risk assessment / Lab safety / Rules & Regulations" briefing.																	
6. Debriefing on Final Oral Presentation & Interim Report																	
Project Work																	
1. Develop objective & scope of research study.																	
2. Identify potential adsorbent.																	
3. Literature review.																	
4. Develop parameter of study.																	
5. Develop experiment matrix.																	
6. Develop methodology of experiment.																	
7. Adsorbent preparation.																	
Presentation																	
1. Preparation on final oral presentation.																	
2. Final oral presentation.																	

Final Year Project 2
REMOVAL OF DYE IN WASTEWATER VIA ADSORPTION USING AGRICULTURAL WASTE (NATURAL SORBENT)
PLANNING SCHEDULE

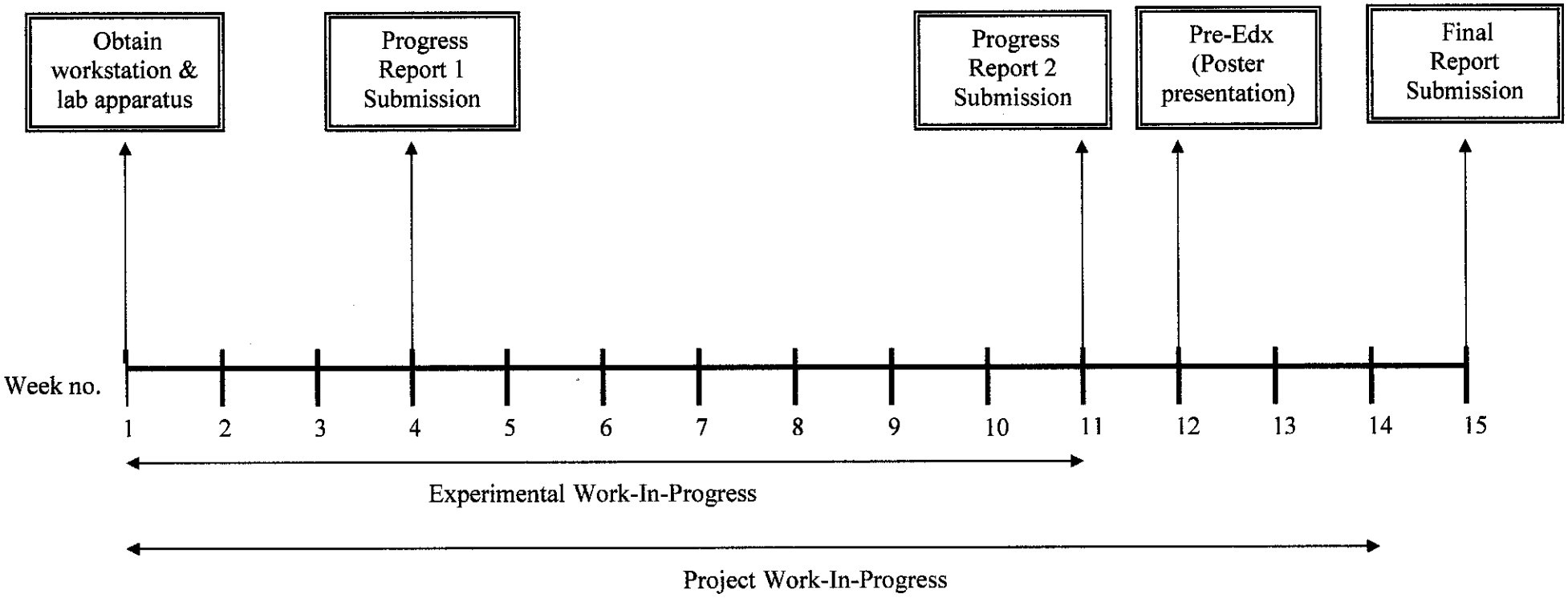
	WEEK NUMBER																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Paper Work submission																Study Week	Final Examination				
1. Progress report 1.																					
2. Progress report 2. (Draft of Final report)																					
3. Final report (CD & Softbound)																					
4. Hardbound copies																					
Briefing & Seminar																					
1. FYP briefing.																					
2. Seminar (5% of course evaluation)																					
Project Work																					
1. Obtain workstation.																					
2. Obtain lab apparatus & glassware.																					
3. Develop dye calibration curve.																					
4. To run experiment 1; effect of particle size.																					
5. To run experiment 2; effect of mass of adsorbent.																					
6. To run experiment 3; effect of initial dye concentration.																					
7. Develop analysis of the experiment (discussion part).																					
Presentation																					
1. Preparation on pre-EDX (poster presentation)																					
2. Pre-EDX (poster presentation).																					
3. Preparation on final oral presentation.																					
4. Final oral presentation.																					

APPENDIX 2

Key Milestone for Final Year Project I.



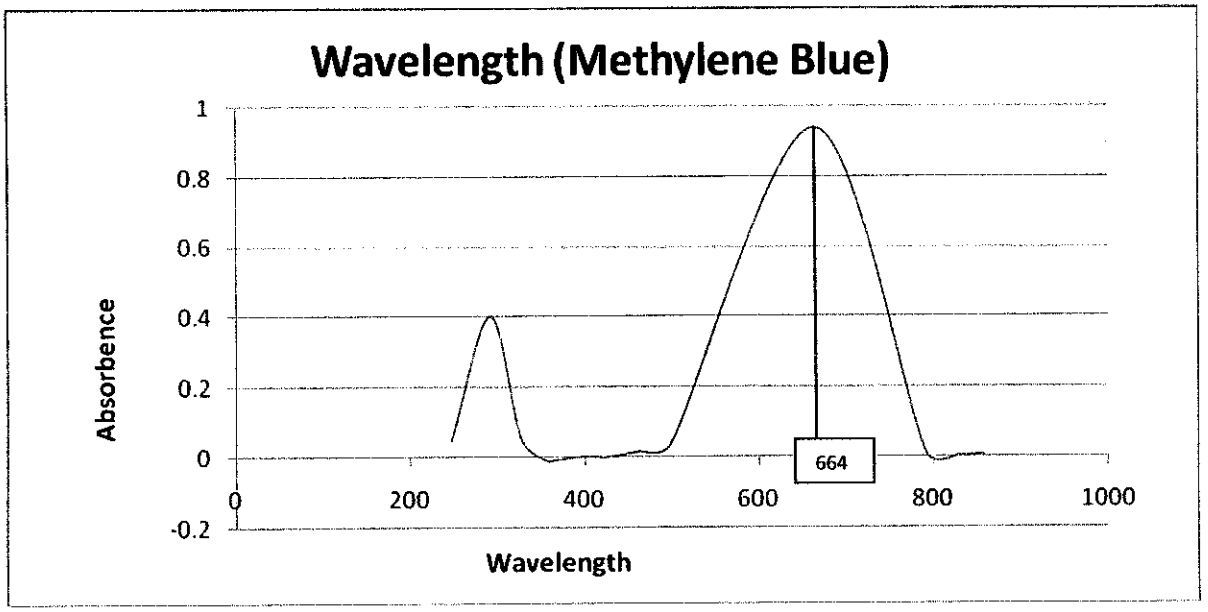
Key Milestone for Final Year Project II.



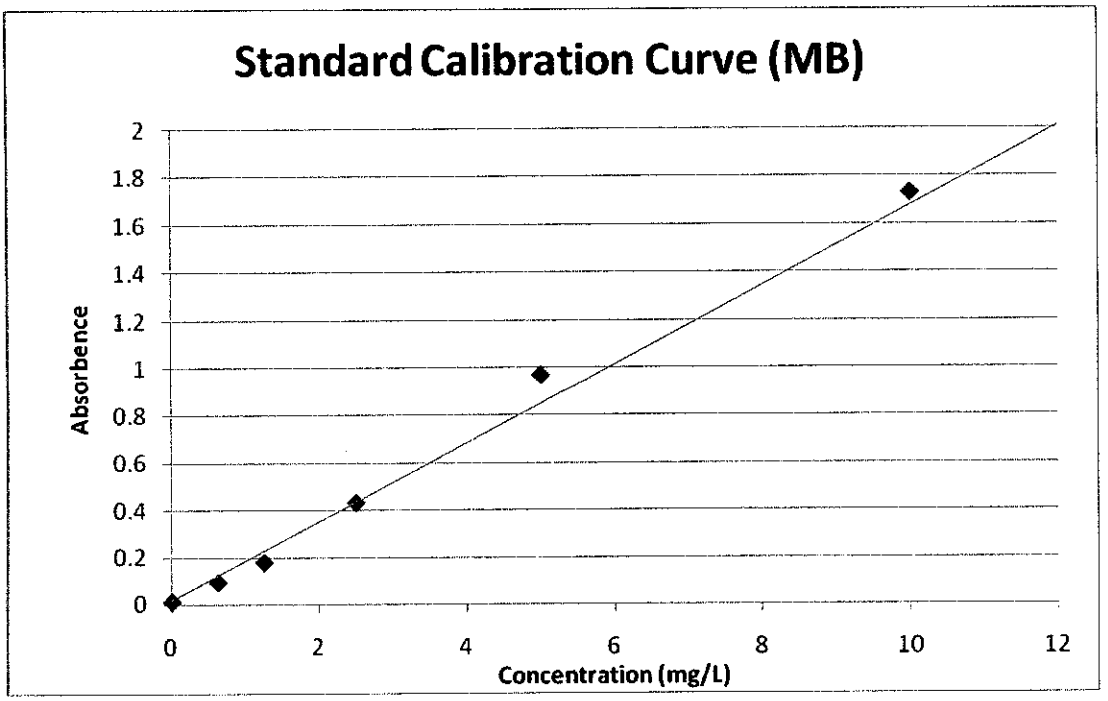
*Final presentation is after week 15. Date to be announced.
*Hardbound submission is after final oral presentation. Due on 12th June2009.

Appendix 3 – Dye standard calibration curve.

Wavelength of Methylene Blue at visible region.



Standard Calibration Curve of Methylene Blue.



Example of dilution calculation to construct the standard curve.

Using

$M_1V_1 = M_2V_2$

M_1 = 1000 mg/L

M_2 = 50 mg/L

V_1 = 50 mL

V_2

$$= \frac{1000mg/L \times 50mL}{50mg/L}$$
$$= 1000mL$$

Based from the calculation, in order to get 1000 mL of M_2 solution, 950 mL of distilled water will be added into 50 mL of M_1 solution.