FIXED BED COLUMN FILTRATION USING PINEAPPLE WASTE ACTIVATED CARBON FOR DYE REMOVAL

by

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THESIS DECLARATION

I declare that this thesis entitled "Fixed Bed Column Filtration Using Pineapple Waste Activated Carbon for Dye Removal" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Sign : _____

Name : Fatin Nabilah binti Azman

Date : _____

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LIST OF ABBREVIATIONS

MB	Methylene Blue
MG	Malachite Green
GDP	Gross Domestic Product
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
KOH	Potassium Hydroxide
H_3PO_4	Phosphoric Acid
K_2CO_3	Potassium Carbonate
$ZnCl_2$	Zinc Chloride

LIST OF SYMBOLS

%	Percentage
°C	Degree celcius
µm	Micrometer
nm	Nano meter
cm	Centimetre
g	Gram
ml	Millimeter

Fixed Bed Column Filtration Using Pineapple Waste Activated Carbon For Dye Removal

ABSTRACT

Dyes are used widely in various industries for colouring purpose. Dye wastes are one of the most concerning pollution in Malaysia. They are easily can be identified by human eyes and not easily degradable which bring detrimental effects to the environment and human. However, the disposal of dye can be treated by several alternatives In this study, activated carbon from pineapple waste such as its crown, core and peel were prepared by chemical acid activation using phosphoric acid (H_3PO_4) to remove pure Methylene Blue (MB) and Malachite Green (MG). The study was carried out to study the effects of particle size (125 μm and 335 μm) and adsorbent dosage (5 g and 15 g) by using fixed bed column experiment. The results obtained from this study showed that the highest removal for MB were 15 g dosage of pineapple peel activated carbon for both size (125 μm - 99.96%, 335 μm - 99.97%) while for MG were also 15 g dosage for both size (125 μm - 99.96%, 335 μm - 99.97%). This study shows that pineapple waste can be converted into something beneficial like activated carbon and can reduce the problem of waste abundance.

‘Fixed Bed Column Filtration’ Menggunakan Karbon Teraktif Daripada Sisa Nanas Sebagai Penyingkir Pewarna

ABSTRAK

Pewarna digunakan secara meluas dalam pelbagai industri untuk tujuan mewarna. Sisa buangan terhasil daripada pewarna merupakan salah satu penyumbang kepada masalah pencemaran di Malaysia. Sisa buangan pewarna mudah dikenal pasti oleh mata manusia kerana ia tidak mudah terurai sekaligus membawa kesan yang buruk kepada alam sekitar dan juga manusia. Walaubagaimanapun, masalah pelupusan kesan pewarna ini dapat diselesaikan dengan beberapa alternatif. Dalam kajian ini, karbon teraktif dihasilkan daripada sisa nanas iaitu jambul, empulur dan kulit menerusi pengaktifan kimia oleh asid fosforik (H_3PO_4) digunakan untuk menyingkirkan Metilena Biru (MB) dan Malakit Hijau (MG). Kajian ini dilaksanakan untuk mengkaji kesan saiz partikal (125 μm dan 335 μm) dan dos penjerap (5 g dan 15 g) menerusi eksperimen ‘fixed bed column filtration’. Keputusan yang diperoleh daripada kajian ini menunjukkan bahawa penyingkiran tertinggi bagi MB adalah dos penjerapan tertinggi daripada karbon teraktif kulit sisa nanas iaitu 15 g bagi kedua - dua saiz partikal (125 μm - 99.96%, 335 μm - 99.97%) manakala bagi MG juga 15 g bagi kedua - dua saiz partikal (125 μm - 99.96%, 335 μm - 99.97%). Kajian ini menunjukkan bahawa sisa nanas boleh dijadikan sesuatu bermanfaat seperti karbon teraktif sekaligus mengurangkan masalah lambakan sisa buangan daripada nanas.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

About 71% of Earth surface is covered with water and the ocean hold about 96.5% of the rest water volume (Perlman, 2018). Thus, Earth become the only planet abundance with water in this solar system. Water is the necessary element among the natural resources and eventually is critical for the survival of all living organism including human, food production, and economic development (Halder & Islam, 2015). The water on surface cycle continuously around, through, and above the Earth as water vapour, liquid water, and ice. 97% of water is from ocean while the rest 3% exists as freshwater (Dwivedi, 2017). From the percentage of the freshwater, about 69% of it is ties up in glacier and ice caps, while 30% is groundwater, and about 0.27% is surface water (Fiore, 2018). Groundwater contained in the aquifer is one of the most important source of water on this planet (Oskin, 2015).

However, due to the rapid increasing of human population, the demand of water supply in industries are surprisingly increase. Water resources also are facing with various threat such as pollution, climate change, urban growth, and landscape change which most of them are caused by human (Al-Badaii, Shuhaimi-Othman, & Gasim, 2013). All these human activities have their own negative impacts on the environment and water resources. Water pollution happens when unwanted effluents enter water system and altering the quality of water (Alrumman S. A., El-kott A. F., & Sherif, 2016). It can be divided into three sources, which are natural sources,

domestic sources, and industrial waste (Alrumman S. A., El-kott A. F., & Sherif, 2016). Industrial wastes of each industry is vary and will be at different location (Alrumman S. A., El-kott A. F., & Sherif, 2016). Some of the effluents generated may contain high inorganic matter, but there are also some industries generates waste that are low inorganic matter but high in toxic chemicals such as metals (Alrumman S. A., El-kott A. F., & Sherif, 2016).

Textile industry is one of the contributor to the pollution of water in Malaysia (Khai et al., 2015). Waste water from textile industries is one of the source of pollution (Norerni, 2013). The waste water from the industries are usually being discharged directly into water body without being treated first (Sridewi, Tan, & Sudesh, 2011). Their effluents containing synthetic dyes have been contributing in the reduction of light penetration into the water and thus affecting photosynthetic activities of the aquatic flora leading to a decrease in food for the aquatic organisms (Y. C. Wong, Senan, & Atiqah, 2013). One of the common content in the waste water is methylene blue ($C_{16}H_{18}N_3SCl.3H_2O_3$.) as it is use in cotton and wools colouring (Khai et al., 2015). It is usually forms a deep blue colour solution when is dissolved into water (Khai et al., 2015). Thus, removal of methylene blue from waste water is essential due to its serious environmental damage if it comes in contact, particularly to human (Y. C. Wong, Senan, & Atiqah, 2013).

Plants and crops such as oil palm plant, coconut, and pineapple has contributed 3.0% towards the country Gross Domestic Products (GDP) according to the Economic Planning Unit (2013). Pineapple is one of the most popular edible fruit in the world (Mahamad, 2015). Malaysia is one of the successful and potentially leading country in pineapple industry. Pineapple or its scientific name is *Ananas comosus* holds the third rank in the world tropical fruit production after banana and

citrus (Nadzirah et al., 2013). Pineapple waste are generally disposed off in the environment and causing serious environmental problems due its waste that requires high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) to decompose (Ratna & Padhi, 2012). Pineapple processing industry produce pineapple waste which are usually consist of its residual pulp, peels and skin (Ratna & Padhi, 2012). This agricultural waste is suitable to be used for methylene blue removal in this study because of its abundance amount found in Malaysia (Ratna & Padhi, 2012). Not only lower the cost in disposing, pineapple waste as adsorbent can prevent on-site burning.

1.2 Problem Statement

Dye wastes is one of the most concerning pollution in Malaysia because they can be easily seen by human eyes and not easily biodegradable (Ong, 2011). Dyes are usually be founded in trace quantities in the thread effluents of many industries. Methylene blue (MB) is one of the most common type of dye found in the effluents. MB is a compound consisting of dark green crystal or crystalline powder, having a bronze-like luster (El-Ashtoukhy & Fouad, 2015). Usually it brings harmful effects to any living things who consumed it. While the negative effects to the environment are like light pollution and ecosystem disturbance (Sathishkumar, 2011). Malachite green (MG) is a water soluble cationic dye that appears as green crystalline powder which belongs to triphenylmethane category (Raval, Prapti U., & Nisha K., 2016). MG is environmentally persistent and may damage nervous system, brain and liver when ingested (Raval, Prapti U., & Nisha K., 2017). It is also acutely toxic to a wide range of aquatic and terrestrial animals (Raval, Prapti U., & Nisha K., 2017). The harmful contamination must be removed immediately. Several methods can be

used to remove methylene blue from water body, one of it is adsorption. As the country produced a great amount of agricultural waste every year, it has a lot of underutilized wastes come from year-around fruit. The common waste generated from pineapple are it peel, crown, and core. These parts are normally being thrown away after harvesting without being knowing the value behind it. From the waste, it can be generated to an activated carbon. This production can lead to minimization of waste production and thus, can reduce the amount of dye in water body.

1.3 Objectives

1. To determine the capability of fixed bed filtration column using pineapple core, pineapple peel and pineapple leaf activated carbon.
2. To compare the efficiency of the fixed bed filtration column from different part of pineapple waste for MB and MG removal in aqueous solution.

1.4 Significant of Study

Rapid development of urban area has caused increasing the demand in industry sectors. The thrive development of the sector however brings along several detrimental impacts to the environment (Rosenblum, Horvath, & Hendrickson, 2000) such as water pollution. One of the source of water pollution is coming from dyeing industry (Kant, 2012). The mass production produced large amount of effluents with a high concentration of pollutants which are required extensive treatment before being discharged into the environment (Subki & Rohasliney, 2011).

Thus, to solve this issue it is necessary to treat the effluent before it being released to the environment. One of the solution is by adsorption method (Karthik et al., 2014). Activated carbon is an excellent material in number of application process

which are purification of water (Orawan et al., 2002), decolourization (Li, Qi, & Gao, 2015) and drinking water treatment (Jeswani et al., 2015). Activated carbon has particular characteristics for adsorption process. They have high porosity, large surface area, high surface reactivity and ease of compaction into a packed bed (Arena, Lee, & Clift, 2016).

Also, activated carbon can be produced from various different kind of fossil or biogenic raw material (Mohammad-Khah & Ansari, 2009). In this study pineapple waste has been chose as raw material of activated carbon production to treat MB and MG. As Malaysia is a country that harvest pineapple every year, the waste from the production are not used. From the waste is burn, it is better to turn into something useful. The utilization of pineapple waste as source of activated brings a major help in reducing the number of pineapple waste. From this study, it is only help in managing agricultural waste but also can provide a material to treat water quality issues.

CHAPTER 2

LITERATURE REVIEW

2.1 Dyes

Dyes molecules are complex compared to other most common organic compounds. Even though they have their own complexity, but dye structures shares a number of common features (Broadbent, 2001). Majority of dye molecules consist a number of aromatic rings, such as benzene or naphthalene, and linked in a full conjugated system (Broadbent, 2001). This molecule shows that there is a long sequence of alternating single bond and double bonds between the carbon with another atom, which is known as chromophore (colour-donating group) (Broadbent, 2001). This conjugated system allows electron extensive delocalization from the double bond with smaller energy difference in between the occupied and unoccupied molecular orbitals for these electrons (Broadbent, 2001). To make the molecular structure coloured, it needs at least five to six conjugated double bonds (Broadbent, 2001). There are many types of dyes depend on their chemical structure or chromophore. The most important groups of dyes are anthraquinone, phthalocyanine, triarylmethane, and azo dyes.

2.1.1 Natural dyes

Natural dyes defined dyes which were derived from the natural sources like plants, animals and minerals (Samanta A. K. & A., 2011). Previously in ancient time, dyes are synthesis from natural sources such as harvesting natural fruits, vegetables and other items, boiling them and submerged the fabrics into the dye bath (Goetz, 2008) (Table 2.1). Also, certain types of roots, leaves, or barks can be manipulated in the liquid form to be used as dyes (Goetz, 2008) (Table 2.1). Most of natural dyes were non-substantive and must be applied on textiles by the help of mordants which usually metallic salt. The reason of it because metallic salt was having affinity for both the colouring matter and the fibre. Usually transition metal ions had strong coordinating power capable to form weak to medium attraction forces. This attraction force then acted as bridging material to create substantivity of natural dyes during impregnation of textile material with metallic salt.

Table 2.1 Sources of Natural Dye (Vankar, 2000)

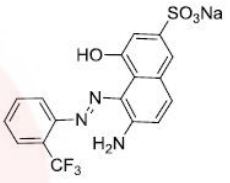
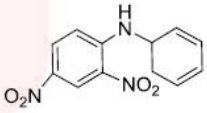
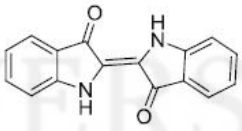
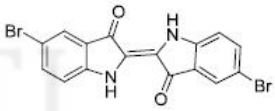
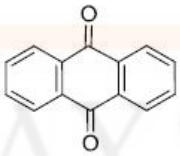
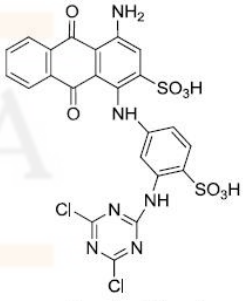
Sources of Natural Dyes	Description
Plant and animal sources	Extracted from the roots, stems, leaves, flowers, fruits of various plants, dried bodies of certain insects, and minerals
By-products (especially lac dye)	Extracted from the effluent
Chemical synthesis	Involves synthesis of dyes with molecular structures Similar to natural dyes
Tissue or cell culture	Synthesised from fungi

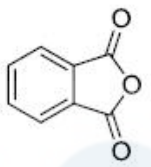
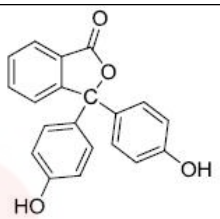
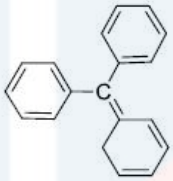
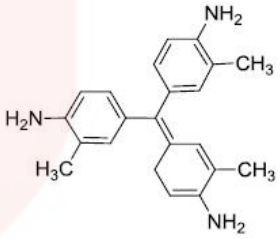
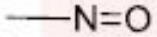
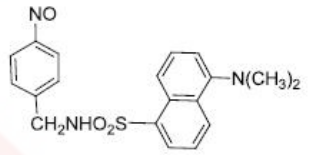
Using natural dyes as colouring brought advantageous against synthetic dyes. The shade produced usually were soft and soothing to human eyes (Samanta A. K. & A., 2011). Unlikely to non-renewable raw materials for synthetic dyes making, natural dyes usually are renewable and biodegradable. In some cases, the waste produced during the process became ideal fertilizer for the use in agricultural fields, thus creating less disposal waste problems (Samanta A. K. & A., 2011).

2.1.2 Classification of textile dyes

Textile dyes have been classified according to their chemical structural group like azo dyes, nitro dyes, indigo dyes, anthraquinone dyes, phtalein dyes, triphenyl dyes, triphenyl methyl dyes, nitrate dyes and such more (Harfi, 2017). Also, textile dyes can be classified according to their industrial application. Table 2.2 presents the textile dyes classification with their chromophore.

Table 2.2 Classification of dye (Harfi, 2017)

Class	Chromophore	Example
Azo	-N=N-	 Acid Red 337
Nitro dyes		 Disperse yellow 14
Indigoid dyes		 C.I. Vat Blue 35
Anthraquinone dyes		 Reactive Blue 4

Phthalein dyes		 Phenolphtaleine
Triphenyl methyl dyes		 Basic violet 2
Nitroso dyes		 Fluorescent-labeled nitroso compound (DNSBA-NO) were synthesized by methods[8].

Azo dyes are compounds that consisted of diazotized amine coupled to an amine or phenol and contained one or more azo linkages (Chung, 2016a). Azo dyes are the largest class of synthetic dyes where approximately 70% all dyes used in industries were azo dyes. They mostly are used in industries like textiles, cosmetic, leather, pharmaceutical, paper, paint and food.

Nitro dyes are relatively small but old class of colourants used on account of their ease of manufacture and high light-fastness. They were usually contained NO_2 group in ortho-position to an electron donating substituent which usually NH_2. Nitro dyes commonly are found as deeply or dirty yellow to brown coloured. Because of its small molecular size, nitro dyes became important for dyeing polyester fibers.

Anthraquinone dyes are rich in violet through blue to green that offers bright blue shades which have very good light fastness (Sekar, 2011). It contains sulfonic

acid groups that retain them soluble in water. Anthraquinone dyes are substantive for wool and silk because they had affinity for these type of fibres without the help of mordants (Sampaolo, 2016).

Phthalein dyes is a part of major class of acid-base indicators. They are insoluble in water but soluble in alcohol. Phthalein dyes also colourless in acid medium but coloured in alkaline medium. The colours they usually exhibited were red, pink, magenta, purple, violet, blue and greenish-blue colour in basic pH.

These dyes then are classified according to their usage and application by the principal system accepted by the Colour Index. Majority of dyes types used for dyeing cotton, polyester and polyester-cotton blends. The classification of dyes are presented by the Table 2.3 below.

Table 2.3 Types and characteristics of synthetic dye (Goetz, 2008)

Types of synthetic dye	**Characteristics of synthetic dye**
Acid dyes	• Produce bright colour • Do not fade off from the fabric • Used in protein fibres
Premetalized acid dyes	• Less bright • Excellent fastness to light and sweat
Chrome dyes	• Brighter than permetalized • Dull colour • Excellent fastness to light, washing, and perspiration
Cationic dyes	• Produce bright colour • Excellent fastness to light, laundering, perspiration, and crocking on synthetics fibres • Poor fastness to washing and light on natural fibres
Direct dyes	• Excellent fastness to perspiration and dry cleaning • Poor fastness to washing and varied light fastness • Excellent fastness to laundering

Disperse dyes	• Wash fastness with disperse dyes varies with the fibers- poor on acetate, excellent on polyester
Naphthol dyes	• Bright shade of colour • Excellent fastness in all areas, but difficult to match the shades
Sulphur dyes	• Dull shades - navy, black, and brown • Excellent fastness in most areas, but are weak when exposed to chlorine.
Vat dyes	• Excellent fastness in all areas, especially to chlorine and bleach

2.1.3 Methylene blue

Methylene blue (MB), $C_{16}H_{18}N_3SCl$ physically appeared as bright greenish blue organic dye belong to phenothiazine family (Sampaolo, 2017). The chemical structure of MB is showed in Figure 2.1 below. When dissolved in water, MB forms a deep blue solution (Y. C. Wong, Senan, & Atiqah, 2013). MB used as a bacteriologic stain and also as an indicator. It inhibits guanylate cyclase that used to treat cyanide poisoning and to lower methemogoblin levels.

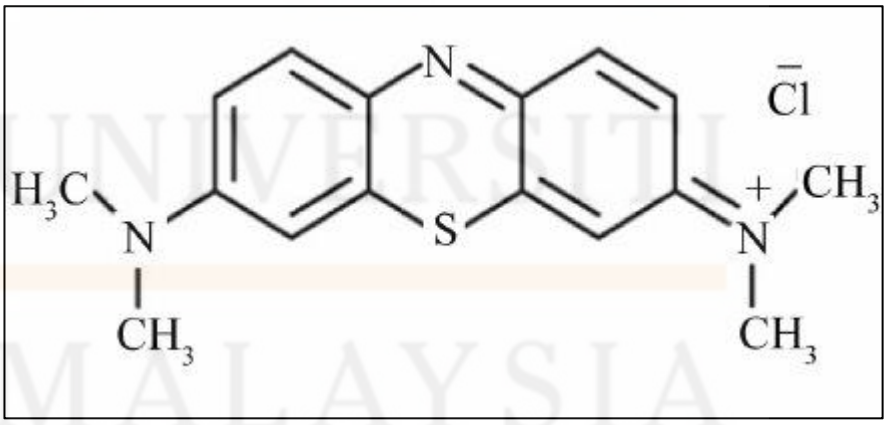


Figure 2.1 : Chemical structure of Methylene Blue (Source : (Elmorsi, 2011))

This cationic dye is commonly used for colouring purpose for dyeing cotton, wool and silk (Elmorsi, 2011). Although MB is not too hazardous, but it may brought some detrimental effect if being exposed to it (El-Ashtoukhy & Fouad, 2015). Acute exposure of MB may brought several health issues to human such as increase in heart rate, vomiting, shock, jaundice and tissue necrosis in human (Kumar & Kumaran, 2005).

2.1.4 Malachite green

Malachite green (MG), $C_{23}H_{25}ClN_2$ physically appeared as green crystallize powder with a metallic lustre (Y. C. Wong, Senan, & Atiqah, 2013) belongs to triphenyl-methane group (Rajabi et al., 2016). The chemical structure of MG is shown in Figure 2.2 below. The colour of MG in aqueous solution is greenish blue (Khatod & Singh Thakur, 2011).

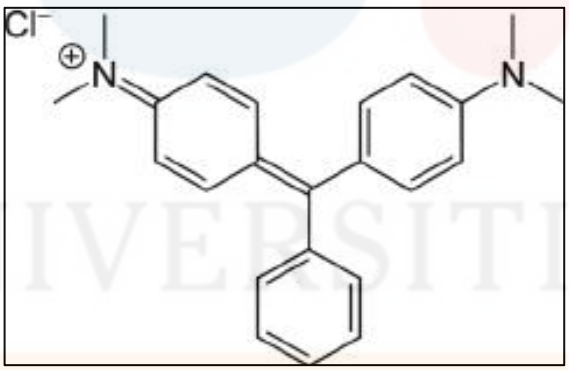


Figure 2.2 : Chemical structure of Malachite Green (Source : (Rajabi et al., 2016))

This water soluble cationic dye commercially is used for colouring purpose for cotton, wool, silk, leather products and also in acrylic industries (Raval, Prapti U., & Nisha K., 2017). In pharmaceutical field, MG also used for antiseptic and fungicidal for human (Raval, Prapti U., & Nisha K., 2017). Severe health problem such as damage to nervous system, brain and liver may be happen if MG is ingested (Raval,

Prapti U., & Nisha K., 2017). It is toxicity to mammalian cells and can cause kidney tumour in mice and reproductive problems in rabbit and fish (Anbia & Ghaffari, 2011).

2.2 Dyes Pollution in Industry

Direct discharge of textile waste water into water body caused water pollution. Textile industries are facing a challenge in the field of quality and the productivity resulted from globalization of the world market (Alves, 2012). 20% of global water pollution is sourced from textile processing, according to World Bank (Scott, 2015). Statistic has been recorded that, every year about 280 000 tons of textile dyes are discharged in the textile industry (Tao, 2006). In 2012, exceed half of $1.25 billion India worth on textile exports to the U.S.A from the southern city of Tiruppur (Scott, 2015). The extensive usage of synthetic in textile waste water are usually treated before it leaves the textile plant. The rational is dye is synthetically produced and has complex molecular structure which make it more stable and hard to be degraded (Forgacs, Cserháti, & Oros, 2004). Most of the contaminants are poisonous and highly can damage human health whether directly or indirectly (Rita, 2012). Due to the higher amount of textile effluent, it highly bring detrimental effects on environmental degradation and human illness (Rita, 2012).

Textile materials can cause allergic reactions (Akarslan & Demiralay, 2015). The materials from textile can be very carcinogenic and mutagenic. It has been observed that painters has developed bladder cancer after a long-time exposure to azo dyes (Myslak, Bolt, & Brockmann, 1991). These kind of compound mainly metabolise at the intestinal wall and in the liver which producing free aromatic amines that are potentially carcinogenic and mutagenic (Gingell, Bridges, &

Williams, 1971). Since past, formaldehyde-containing resins have been used in clothing industry as a wrinkle resistant fabrics (Akarslan & Demiralay, 2015). The resins used are methylol reactive groups to cross link cellulose fibre in cotton, linen, and rayon (Akarslan & Demiralay, 2015). Dyes also can cause allergic, eyes irritation, dermatitis, and skin irritation to human if come in contact or exposure (Chung, 2016b).

From environmental view, dye waste water is considered as a serious pollution problem because the content of its is high in colour and organic content (Paul, 2008). Aquatic life and habitat food web will be altered and damaged if the dye waste water is directly discharged into water resources even though in a small amount (Paul, 2008). Not only that, the physical characteristics of dye itself, the colour of the effluents also brings lower aesthetic value (Paul, 2008). The non-biodegrdable nature of the dyes itself can reducing the diversity of the aquatic by blocking the penetration of sunlight through the water (Paul, 2008). When the sunlight is blocked from entering the water, green plants living inside the water can not undergo photosynthesis process which later can lead to death. The coloured effluents also can affect the aquatic flora and fauna, therefore creating more water borne diseases (Paul, 2008).

2.3 Treatment of Dye

Dyeing industries is one of the largest water consuming industries (Sivamani & Leena Grace, 2009). The wastewater coming from the dyeing industries contains various chemicals and colouring compounds that require proper treatment before it is released into any water bodies (Sivamani & Leena Grace, 2009). The release of untreated effluents into the environment can be very damaging to the receiving water

bodies (Sivamani & Leena Grace, 2009). Commonly, the untreated dyes waste waters from dyes production and dyeing industries have a great colour variety and difficult to be degraded due to its complex chemical structure (Babu et al., 2007). In 80s, people awareness on dye wastes started to increase and eventually more information of dye available which has triggered dye manufactures consumers and government to take measures on dye waste waters treatment (Gupta & Suhas, 2009). Thus, it makes the removal of dye from the coming effluents are environmental major concern. In Malaysia, Environmental Quality Regulations 1979 is the body that responsible to monitor the discharged of effluents from industries. There are a few ways of treatment of dye removal and decolourization where each of it has their own advantages and disadvantages (Ratna & Padhi, 2012). Some of they are physical, chemical, physio-chemical, and bio-chemical process (Ratna & Padhi, 2012).

Physical process of treating waste water especially that contain dyes consists of membrane filtration, chemical precipitation, carbon adsorption, and ion exchange (Paul, 2008). In previous years, there is several research have been done on investigating waste water treatment using adsorption process (Ta Wee Seow & Lim, 2016). Adsorption is a process where a multi-components fluid or gas mixture is attached to the surface of a solid adsorbent forming an attachment through physical or chemical bond (Sasaki et al., 2014). Adsorbent is the substance that providing solid surface while the material removed from the liquid phase is known as adsorbate (Ta Wee Seow & Lim, 2016). Tiny chemical particles suspended that are removed from another phase are considered as contaminants, where it is separated from those phase through adsorption process that bonded onto solid phase (Lenntech, 2014). They are four steps involve in adsorption process of dye molecule (Al-Qodah, 2000). First, it involves the diffusion or convection of dye molecules through the bulk of

solution. Next, dye molecules will diffuse through a diffusional boundary layer (Al-Qodah, 2000). This is followed by the diffusion of dye molecules from the surface into the adsorbent materials (Al-Qodah, 2000). And lastly, the molecule of dye will attach to the surface of the materials through molecular interactions (Al-Qodah, 2000).

2.4 Column Study

In this study, the removal of MB and MG were done in fixed bed column adsorption. Fixed bed adsorption mechanism usually used for gas and liquid pollution control (Auta & Hameed, 2014). Fixed bed column is easy to use in laboratory but not too convenient to be used for industrial application (Chandra P. Dwivedi, 2008). Fixed bed columns were widely used in various chemicals industries because of their simple operation with encouraging results (Chandra P. Dwivedi, 2008). In column practice, adsorbate was continuously in contact with adsorbent which providing the required concentration gradient between adsorbent and adsorbate for adsorption process. Bed column also as an effective process for adsorption/desorption which made the best use of the concentration difference and allows more efficient utilization of adsorbent capacity and results in better quality of effluent (Oguz, 2017). Through fixed bed column set-up, large amount of wastewaters can be treated continuously with a defined quantity of adsorbent in the column.

In fixed bed column system, the solute concentration of effluent is free of the target solute until breakthrough of solute occurs (Hamdaoui, 2006). It is designed for the polluted effluent to come in contact with a fixed amount of adsorbent (Malkoc & Nuhoglu, 2006). Fixed bed column can be done in two way which were down flow

column and up flow column (Wan Muhammad Mutammimul Ula, 2012). In this study, down flow column was applied as this was the most common type of adsorption column for wastewater treatment. While up flow column were mostly operated in the expended-bed mode where used when wastewater flows into the column contained significant amount of suspended particles.

Practices of column type continuous flow type are more useful compared to batch treatment. This set-up is an easy scale for laboratory procedure and simple to operate. Also, column experiment could attain high yield result. An accurate prediction for adsorption process could be obtained through small scale column studies (Al-Degs et al., 2009). Usually most of column studies considered the effects of flow rate, adsorbate concentration and adsorbent mass or depth. Furthermore, fixed bed column set-up always bring the effluent in contact constantly with the adsorbent. This condition provided the needed concentration slope between the adsorbent and the effluent for adsorption process (Wan Muhammad Mutammimul Ula, 2012).

2.5 Activated Carbon

Activated carbon is the commercial name of a porous group carbon manufactured by the treatment of a char with oxidizing gases or by carbonization of carbonaceous materials impregnated with dehydrating chemicals (Rodríguez-Reinoso, 2001). The properties of activated carbon are its specific surface area, iodine index, tannin index, methylene blue index, butane index, carbon tetrachloride index, dechlorination half-value length, density, hardness number, ash content, porosity and particle size distribution Activated carbon is used as a potential adsorbent in water and waste water treatment because of the porous carbonaceous

adsorbent have high carbon content and low inorganic matter (Gerçel & Gerçel, 2015). The porosity of the carbon itself make it enable to has large surface area for adsorption (Pradhan, 2011), where adsorption process is a process that molecules of gas, vapour, or liquid concentrate at contacting surface without any chemical reaction takes place (Ioannidou & Zabaniotou, 2007).

Raw material for activated carbon production comes from any cheap material with high carbon content and low inorganic (Tsai, Chang, & Lee, 1997) such as agricultural waste like risk husk and saw dust (Taimur et al., 2013). Agricultural by-products are considered also as important source material for the production of activated carbons as they are renewable and low cost materials (Oubagaranadin & Murthy, 2011). Utilization of raw material waste in activated carbon preparation is an alternative to the expensive commercial activated carbons. These materials are found to be particularly useful due to their good kinetic properties and higher adsorption capacities. Because of its higher adsorption capacity, it can absorb different sort of substance from gaseous or liquid state (Martinez, 2003).

To produce activated carbon, it needed raw material from agricultural waste, forestry or biomass. The most important thing is the precursor must be rich in carbon content for the preparation. Activated carbon may be obtained by physical activation with either steam or carbon dioxide (CO_2) gaseous. Another way is through chemical activation. This process involving reaction with strongly reacting chemicals such as zinc chloride ($ZnCl_2$), phosphoric acid (H_3PO_4) and alkali-metal hydroxide such as sodium hydroxide (NaOH) and potassium hydroxide (KOH).

2.5.1 Physical activation

This activation method involves two steps in production carbonization then followed by activation. The raw material is needed to be carbonized first at 400°C to 800°C then the carbonized carbon will be activated at high temperature range between 800°C to 1000°C in the presence of oxidation agent steam, carbon dioxide, and air (Bubanale & Shivashankar, 2017). Carbon dioxide has is usually used as activation gas because it is clean, easy to handle, and it helps in controlling the activation process due to the slow rate of reaction at around 800°C (Zhang et al., 2004). The activated carbon produced from physical activation usually do not have satisfactory characteristics in order to be used as adsorbent in filtration (Bubanale & Shivashankar, 2017).

2.5.2 Chemical activation

This process only needed one step where both carbonization and activation take place in only single step (Bubanale & Shivashankar, 2017). The precursor is mixed with chemical agents where it acts as an oxidant and dehydrating agent and kept at high temperature (Bubanale & Shivashankar, 2017). The most used chemical agent for activation are potassium hydroxide (KOH), phosphoric acid (H_3PO_4), zinc chloride ($ZnCl_2$), and potassium carbonate (K_2CO_3) (Bubanale & Shivashankar, 2017). This activation process is performed at lower temperature where it results a better development of porous structure (Bubanale & Shivashankar, 2017). Chemically activated carbons have good thermal stability, characteristic porous structure, and large internal surface area and porous volume (Oubagaranadin & Murthy, 2011).

2.5.3 Types of activated carbon

Activated carbons are complex products which are difficult to classify on the basis of their behaviour, surface characteristics and preparation methods. However, some broad classification is made for general purpose based on their physical characteristics which are powdered activated carbon (PAC), granular activated carbon (GAC), impregnated carbon and many others.

Powdered activated carbon (PAC)

The particle size of PAC is usually less than 0.1 mm and in common range in between 0.015 mm to 0.025 mm (Pradhan, 2011). PAC is commonly used because it has great surface area and good ability to adsorb compound. There are several sectors that are widely using PAC such as industrial and municipal wastewater treatment, sugar decolourization, food industry, pharmaceutical and mercury and dioxin removal from flue gas stream (Gottipati & Mishra, 2013). Figure 2. below shows the physical of PAC.

Figure 2.3 : Powdered Activated Carbon (PAC)
(Source :http://www.activeglobalinc.com/PAC_Wood_Base.php)

Granular activated carbon (GAC)

GAC has relatively large size of particle compared to PAC and consequently presents a smaller external surface area (Pradhan, 2011). These GAC are preferred

for all adsorption of gases and vapours because their rate of diffusion are faster. The size of GAC is usually designated by sizes such as 8×20, 20×40, or 8×30 for liquid phase applications and 4×6, 4×8 or 4×10 for vapour phase applications (Pradhan, 2011). Figure 2. below shows the physical of GAC.

Figure 2.4 : Granular activated carbon (GAC) (Source : http://www.activeglobalinc.com/GAC_Coconut_Shell.php)

Impregnated carbon

Porous carbon containing several types of inorganic impregnant such as iodine, silver, cations such as Aluminium (Al), Manganese (Mg), Ferum (Fe), Lithium (Li) and Calcium (Ca) (Pradhan, 2011). Impregnated carbon by cation is usually prepared for specific application in air pollution control especially in museum and gallery (Pradhan, 2011).

2.5.4 Application of Activated Carbon

Activated carbon is widely used in various fields and sectors. Usually activated carbon is used in gas purification process, gold purification process, metal extraction, water purification, sewage treatment and air filtration (Pradhan, 2011). In wastewater treatment, activated carbon is used because it posses several desirable properties that enables its usage in adsorption due to its large surface area and porosity (S. Wong et al., 2018). Poisonous heavy metal ions such as lead, cadmium and mercury can be

removed from aqueous through activated carbon. The adsorption process takes place due to the surface complex formation between metal ion and acidic surface function group of activated carbon (Mohammad-Khah & Ansari, 2009). The uses of activated carbon is not only limited to adsorption of heavy metal only, it is also used in environmental and ecological field. Pollutants from air and water can be removed both on field and industrial processes such as drinking water filtration, air purification, volatile organic compounds capture and many other processes. As in medical field, activated carbon is used to treat food poisoning (J Alkhatib, Khalid, & Zailaey, 2015). Activated charcoal has a surface area about 1000 m^2/g and has the ability to adsorb many drugs (J Alkhatib, Khalid, & Zailaey, 2015). All the mentioned application of activated carbon are just a few to list, however activated carbon is used widely in various field nowadays.

2.6 Pineapple Waste as Activated Carbon

Pineapple is grown in many country all over the world like in Brazil, Philippines, Thailand, Malaysia, Indonesia, Hawaii and Costa Rica (Mopoung, 2016). Tropical country like Malaysia is one of the successful and potential country in pineapple industry. Pineapple or its scientific name is *Ananas comosus* is in top three rank in the world tropical fruits after banana and citrus (Selvanathan, Sulaiman, & Subki, 2015). The family of *Ananas comosus* is Bromeliaceae (Toyin, Olakunle, & Adewunmi, 2014). The common species of pineapple found in Malaysia are Moris, N36, Sarawak, Moris Gajah, Gandul, Yankee, Josapine, Masapine and MD2.

However, due to the large-scale production of pineapple, the waste generated especially from crown, core and peel are creating another issue. The waste generated are literally being disposed into open environment due to high cost for proper

disposal (Selvanathan, Sulaiman, & Subki, 2015). This contribute by the selection and elimination of inedible parts of pineapple for human consumption (Upadhyay, P. Lama, & Tawata, 2013). The waste generated laterally contributed to accumulation in agro-based industry yards due to does not having any commercial value and significant contribution. Another reason for the waste production is because of higher level of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) which later add more on difficulties in disposal.

To overcome the disposal problem, study on utilization of pineapple waste is conducted by several researchers in various ways named as bromelain, ethanol, antioxidant, organic acid, anti-dyeing agent, fiber, heavy metal removal, animal feed and energy, the last one is as carbon source (Maurya, Mittal, & Cornel, 2008). Pineapple waste can be transformed into activated carbon for the removal of dye because the cost of producing the adsorbent is low and unconditionally reducing off-site burning issue and preventing improper disposal (Lutpi et al., 2011).

CHAPTER 3

MATERIALS AND METHOD

3.1 Material and instrument

All chemicals and instruments used in this study were listed in Table 3.1 and Table 3.2.

Table 3.2 : List of chemicals used in this study

Chemicals	Brand	Concentration/Mass
Phosphoric acid (H_2PO_4)	Bendozene	40%
Methylene blue	Bendozene	0.5 g
Malachite green	Bendozene	0.5 g

Table 3.3 : List of instrument used in this study

Instrument	Brand	Model
UV-Vis spectrophotometer	HACH	DR5000

3.2 Preparation of Raw Material

Pineapple crown, pineapple peel and pineapple core were used in this research. The pineapple wastes were taken from local market. The parts were cut into smaller pieces and being washed with distilled water. Then, the wastes were dried in the oven for 3 hours at 105°C (Lutpi et al., 2011). The dried pineapple crown, pineapple peel and pineapple core were grounded separately until it became smaller particles. Then the grounded dried pineapple wastes were sieved through 125 μm and 355 μm of sieve.

3.3 Preparation of Adsorbate

About 0.5 g of dye (MB and MG separately) was weighed by using a weighing balance and poured into a 250 ml beaker. About 20 ml of distilled water was poured into the beaker and glass rod was used to stir to ensure the dissolve of dye. After that, the dye solution was poured into a 100 ml volumetric flask and made up until the mark with distilled water. The dye solution was then filtered by using 0.45µm Whatman filter paper. About 5 ml of dye solution was pipetted into a 50 ml volumetric flask and made up to the mark with distilled water. The dye solution was stored in 50 ml of polypropylene bottle and labelled for analysing purpose (Subki, Hashim, & Noor, 2014).

3.4 Activation and Carbonization Process of Pineapple Waste

The oven dried pineapple crown, peel, and core were soaked in boiling solution of 40% phosphoric acid for 1 hour (Baseri, Palanisamy, & Sivakumar, 2012). The pineapple crown, pineapple peel and pineapple core were heated in oven separately at 100°C for 24 hours for drying purpose. After that, they were left at room temperature for 24 hours. Then, they were carbonized separately in Muffler furnace at 500°C for 1 hour. Later, the samples were washed separately with hot distilled water and cold distilled water then dried in oven at 120°C for 2 hours. Each of them were stored in a tight lid container separately with labelled.

3.5 Testing Pure Adsorbate in Spectrophotometer

The prepared pure dye, Methylene Blue (MB) and Malachite Green (MG) were placed on HACH DR 5000 to identify their initial optical density prior to treatment with activated carbon from pineapple peel, core and crown. The initial optical

density of MB was determined as 668 nm and 659 nm for MG (Y. C. Wong, Senan, & Atiqah, 2013). Spectrophotometer HACH DR 5000 operates on principles of UV light absorption by dye being tested. Untreated MB and MG contained higher percentage of pigments colour that being absorbed by the UV light produced in the Spectrophotometer HACH DR 5000. Hence, the absorber detected higher optical density as the colour pigments in the dye absorb the UV radiation which indicated the high concentration of colour.

3.6 Fixed Bed Column Experiment Set-up

The column was made up from plastic material column that being held by retort stand like being shown in Figure 3.1. The bottom part of the column was tied with nylon fitter mesh size less than 150 μm to hold the adsorbent in each column from passing through the nylon fitter. The height of each column was 10 cm with 3 cm of internal diameter which resulted 70.69 cm^3. The flow rate of every set was constant at 0.34 $ml/s^{-1}$and being controlled by burette. The flow rate was determined by collecting some amount of water in a minute. The experiment was conducted in room temperature (Musapatika, 2010). Each of the column had beaker to collect the filtered solution.

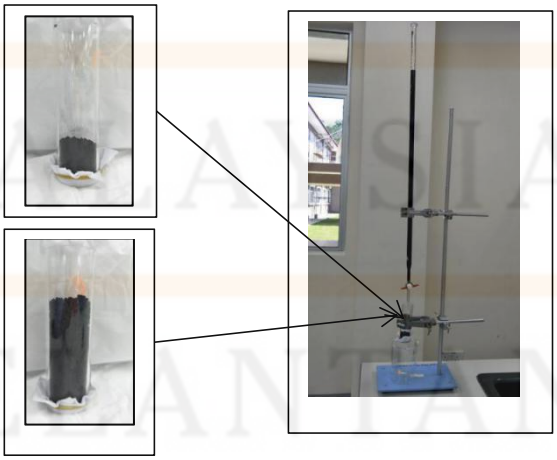


Figure 3.1 : Column experiment set-up

3.6.1 Fixed Bed Column Experiment Set-up for Adsorbent Dosage

The adsorbent dosage fixed in this experiment were 5 g and 15 g. Each of it was weighed before being put into the column at the bottom. The system set-up was shown in Figure 3.2.

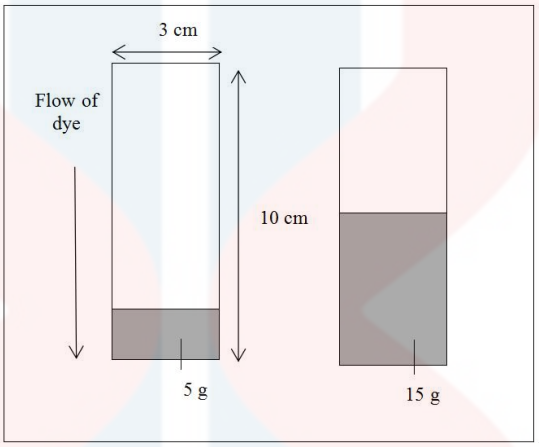


Figure 3.2 : The set-up of fixed bed column experiment for each parts of pineapple adsorbent (adsorbent dosage)

About 50 ml of MB and MG passed through each column to be filtered individually. The concentration of MB and MG and flow rate of each dye were constant. The final adsorbance reading of each filtered solution were taken.

3.6.2 Fixed Bed Column Experiment Set-up for Particle Size

Particle size of the adsorbent used in this experiment were 125 µm and 355 µm of sieve. Each of the adsorbent were put at the botttom of the column like being showed in Figure 3.3 below.

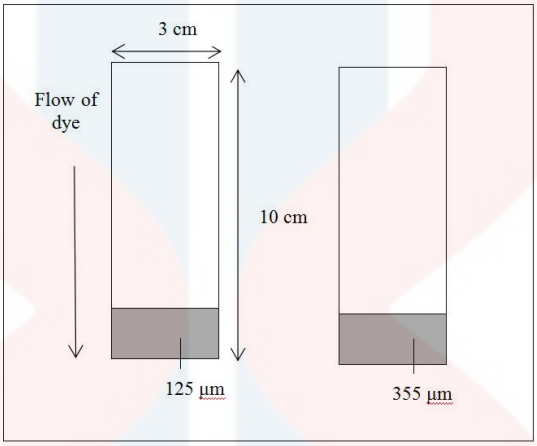


Figure 3.3 : The set-up of fixed bed column experiment for each parts of pineapple adsorbent (particle size)

About 50 ml of MB and MG passed through each column to be filtered individually. The concentration of MB and MG and flow rate of each dye were constant. The final adsorbance reading of each filtered solution were taken.

3.7 Percentage Removal of MB and MG

The percentage removal for MB and MG were calculated by using percentage removal formula :

$$\%\ \text{Removal} = \frac{(C_o - C_t)}{C_o} \times 100\%$$

Where, C_o is the adsorbance value before the dyes were treated with activated carbon while C_t is the adsorbance value after the dyes were treated.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Preparation of Activated Carbon from Pineapple Crown, Core and Peel

Pineapple crown, core and peel as being shown in Figure 4.1 and Figure 4.2 (before and after drying) were used in this research to produce activated carbon from acid (H_2SO_4) activation. These parts were differ from each other in term of vary way. As for pineapple crown, it was the fastest one to dry as the moisture content in that part was least compared with the rest. However, pineapple crown were high in fibre thus, making the grinding process needed to be repeated several times. As for the core, these parts contained the highest amount of sugar which made the grinding process became difficult. During the process, the particles of grind core were melted due to the heat presence when grinding. Due to that, the powder coagulated and blocked the sieve hole made the process a bit difficult. The hardest part was the peel as it was naturally thick and hard. After drying process, this part became more harden which made grinding process a bit difficult to grind until became smaller particles.

a b c

Figure 4.1 : Pineapple crown (a), peel (b) and core (c) before drying

a b c

Figure 4.2 : Pineapple crown (a), peel (b) and core (c) after drying

4.2 Comparison Between Different Parts of Pineapple Waste Activated Carbon

In this research, two parameters (dosage and particle size) were chosen to observe the ability of activated carbon produced from pineapple waste to remove pure dye. Dyes that were used in this research were Methylene Blue (MB) and Malachite Green (MG). The adsorbence data obtained from this study were presented in Appendix A until Appendix D.

4.2.1 Effect of Size Particle and Dosage on Methylene Blue Removal using Different Pineapple Waste Activated Carbon

Table 4.1 recorded the percentage removal of MB using different parts of pineapple waste activated carbon. Factors affecting the value of percentage removal were the particle size of the activated carbon and its dosage.

Table 4.1 : Percentage removal of MB using different pineapple waste activated carbon

	Pineapple crown activated carbon		Pineapple core activated carbon		Pineapple peel activated carbon	
	5 g	15 g	5 g	15 g	5 g	15 g
125 µm	88.27%	99.82%	86.96%	99.63%	97.53%	99.96%
355 µm	93.70%	99.84%	84.47%	99.91%	99.91%	99.97%

The set of data obtained from the experiment was then simplified into bar chart in Figure 4.3 and Figure 4.4. The highest value of MB removal percentage for both adsorbent size were activated carbon from pineapple peel with respective value of 97.53%, 99.96%, 99.91% and 99.97% for each dosage.

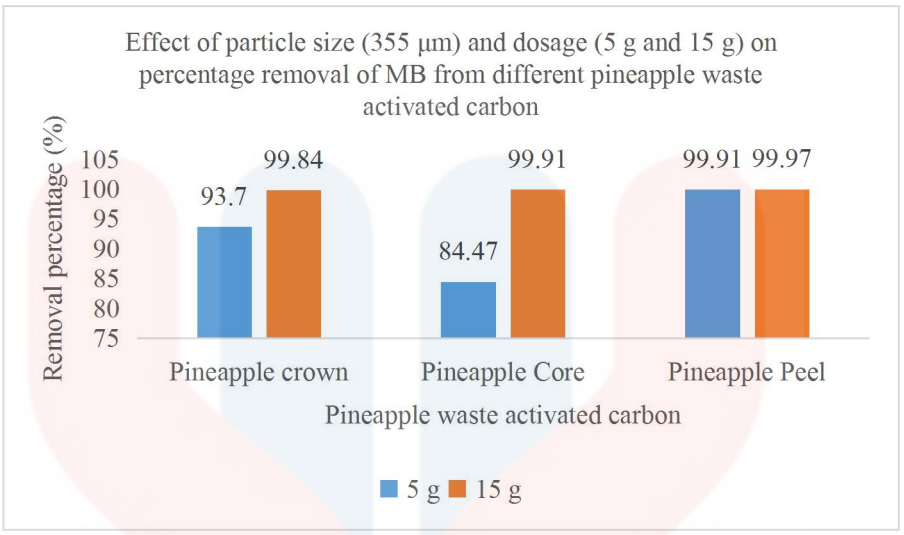


Figure 4.3 : Effect of particle size (355 µm) and dosage (5 g and 15 g) on MB removal

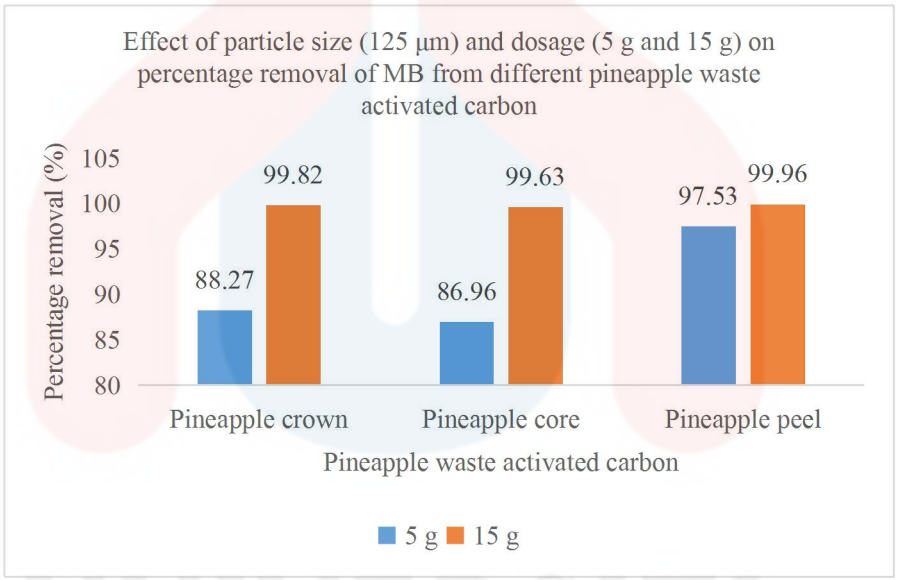


Figure 4.4 : Effect of particle size (125 µm) and dosage (5 g and 15 g) on MB removal

Each set of column was filled with desired dosage of activated carbon before MB was introduced to the system. In the beginning, the surface of activated carbon was not fully covered with the dye yet. It took couple of times for the adsorption process to take place. As the dye was adsorbed by the activated carbon, the process adsorption begun and filtered out the treated dye. The longer the time of dye in contact with activated carbon, the longer the adsorption process take place (Nawaz & Ahsan, 2014). As for 5 g dosage of activated carbon, the height of the activated carbon was about 2.5 cm for each. So when MB was introduced to the system, it did

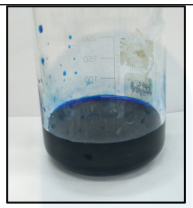
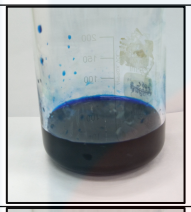
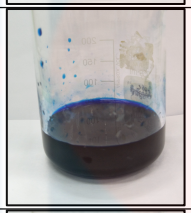
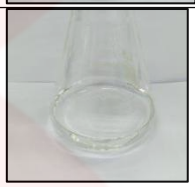
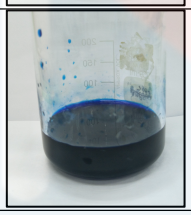
not come in contact for too long thus, shorten the adsorption process. As the whole parts of the activated carbon were wetted with the dye, so the remaining dye flowed into the column did not get to bind on surface area of the activated carbon. The treated dye continuously passed through column.

The highest removal percentage of MB was recorded at 15 g of pineapple waste activated carbon compared to 5 g of dosage. First, the height of the system was higher than the previous dosage. This condition maximize the contact time of dye with activated carbon before it reached the bottom and filtered. As the height increase, the surface area also increase which later allowed more binding place for MB molecules to the activated carbon. So, the colour of treated dye left the column was more clearer than 5 g dosage of activated carbon.

As for parameter particle size of activated carbon, it did not give significant impacts to the percentage removal of MB. As being stated in Table 4.3, the value of percentage removal for each set was major affected by the dosage amount rather than the size particle. The gap difference in removal percentage between the two particle size was not too distinct.

The colour of pure MB after being treated with pineapple peel activated carbon were shown in the Table 4.2. In Appendix E (Table E1 and Table E2), the observation of colour changes for pineapple crown and pineapple core activated carbon were recorded.

Table 4.2 : Obeservation of MB colour before and after treatment

Activated carbon	Particle size (µm)	Dosage (g)	Colour of pure dye before treated	Colour of pure dye after treated	Observation
Pineapple peel	125	5			Pale blue
		15			Clear
	355	5			Clear
		15			Clear

4.2.2 Effect of Size Particle and Dosage on Malachite Green Removal using Different Pineapple Waste Activated Carbon

Table 4.3 recorded the percentage removal of MG using different parts of pineapple waste activated carbon. Factors affecting the value of percentage removal were the particle size of the activated carbon and its dosage.

Table 4.3 : Percentage removal of MG using different pineapple waste activated carbon

	Pineapple crown activated carbon		Pineapple core activated carbon		Pineapple peel activated carbon	
	5 g	15 g	5 g	15 g	5 g	15 g
125 µm	87.93%	99.92%	90.13%	99.82%	99.85%	99.96%
355 µm	85.26%	99.22%	97.69%	98.97%	99.78%	99.97%

The set of data obtained from the experiment was then simplified into bar chart in Figure 4.5 and Figure 4.6. The highest value of MG removal percentage for both adsorbent size were activated carbon from pineapple peel with respective value of 99.85%, 99.96%, 99.78% and 99.97% for each dosage.

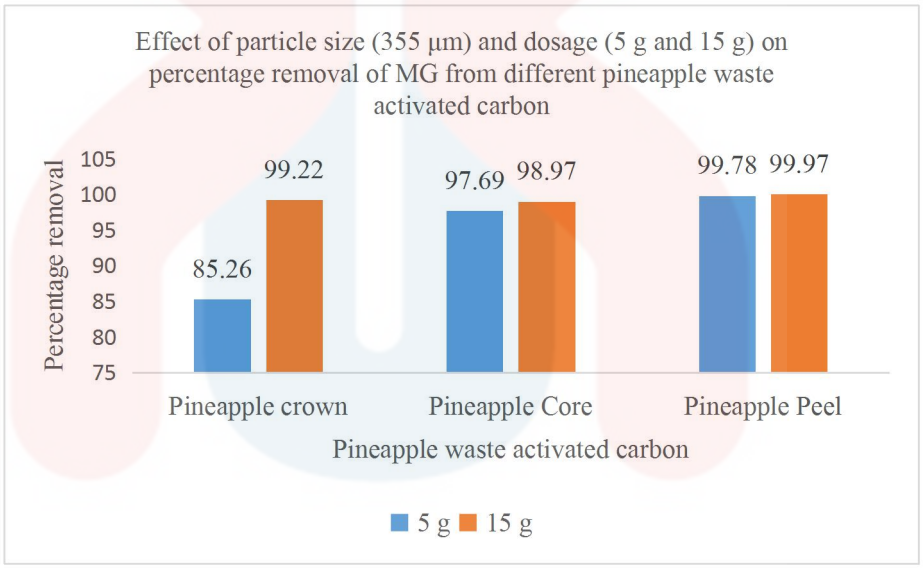


Figure 4.5 : Effect of particle size (355 µm) and dosage (5 g and 15 g) on MG removal

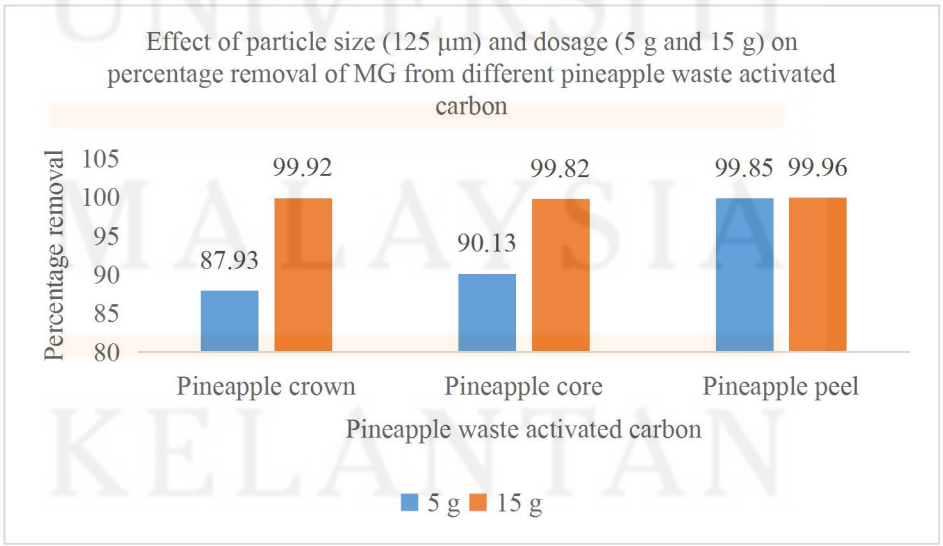


Figure 4.6: Effect of particle size (125 µm) and dosage (5 g and 15 g) on MG removal

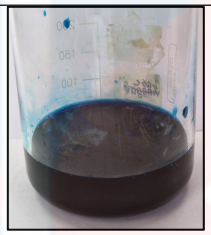
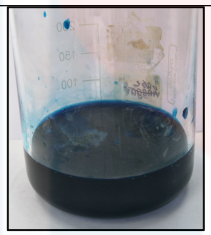
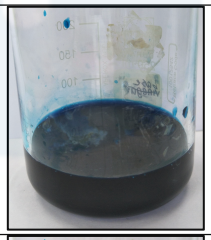
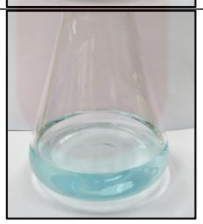
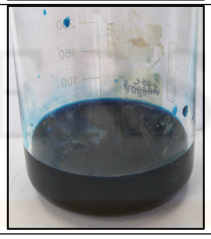
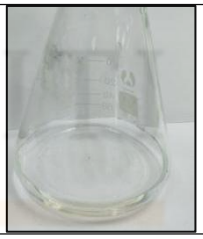
Each set of column was filled with desired dosage of activated carbon before MG was introduced to the system. In the beginning, the surface of activated carbon was not fully covered with the dye yet. It took couple of times for the adsorption process to take place. As the dye was adsorbed by the activated carbon, the process adsorption begun and filtered out the treated dye. The longer the time of dye in contact with activated carbon, the longer the adsorption process take place (Nawaz & Ahsan, 2014). As for 5 g dosage of activated carbon, the height of the activated carbon was about 2.5 cm for each. So when MG was introduced to the system, it did not come in contact for too long thus, shorten the adsorption process. As the whole parts of the activated carbon were wetted with the dye, so the remaining dye flowed into the column did not get to bind on surface area of the activated carbon. The treated dye continuously passed through column.

The highest removal percentage of MG was recorded at 15 g of pineapple waste activated carbon compared to 5 g of dosage. First, the height of the system was higher than the previous dosage. This condition maximize the contact time of dye with activated carbon before it reached the bottom and filtered. As the height increase, the surface area also increase which later allowed more binding place for MB molecules to the activated carbon. So, the colour of treated dye left the column was more clearer than 5 g dosage of activated carbon.

As for parameter particle size of activated carbon, it did not give significant impacts to the percentage removal of MG. As being stated in Table 4.2, the value of percentage removal for each set was major affected by the dosage amount rather than the size particle. The gap difference in removal percentage between the two particle size was not too distinct.

The colour of pure MG after being treated with pineapple peel activated carbon were shown in the Table 4.4 below. In Appendix F (Table F1 and Table F2), the observation of colour changes for pineapple crown and pineapple core activated carbon were recorded.

Table 4.4 : Observation of MG colour before and after treatment

Activated carbon	Particle size (µm)	Dosage (g)	Colour of pure dye before treated	Colour of pure dye after treated	Observation
Pineapple peel	125	5			Very pale blue
		15			Clear
	355	5			Pale blue
		15			Clear

4.3 Best Activated Carbon for Methylene Blue and Malachite Green Dye Treatment

Cellulose, hemicellulose and lignin were the elements that built up pineapple crown, core and peel (María Elena Sánchez Pardo & García, 2014). Inside the cellulose, hemicellulose and lignin, large number of hydroxyl groups (-OH) were present which later gave adsorptive property to the pineapple waste (Zaharia & Suteu, 2012). Also, besides hydroxyl group, there was also carbonyl group (>C=O) that helped in adsorption process. As both carbonyl and hydroxyl group were negatively charged in natural state, it created strong electrostatic attraction with positively charged of MB and MG. The cationic molecule of dyes dissociated and adsorbed to the binding site of pineapple waste activated carbon. This strong attraction allowed adsorption process to take place because the presence of strong attraction of electrostatic between negatively charged pineapple crown, core and peel with positively charged MB and MG (Hadi, Reza Samarghandi, & McKay, 2011).

In this study, activated carbon from pineapple peel showed maximum adsorption of MB and MG with the highest dosage of each size of particle (MB - 99.97%; MG - 99.97%). From the result obtained, it showed that the efficiency of dyes removal increasing with the increase in adsorbent dosage (Ashtaputrey & Ashtaputrey, 2016). This was due to the increasing of adsorbent weight where it provided more available adsorption site for electrostatic attraction between pineapple peel activated carbon with MB and MG (Shahul Hameed, Muthirulan, & Meenakshi Sundaram, 2017).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the results obtained by this study, it showed that agricultural waste such as pineapple waste can be turned into other useful products rather than being burned. By this study it had been proved that pineapple crown, core and peel can be turned into activated carbon for pure dye removal. Those three parts of the waste had the ability of adsorption thus making it successful to become activated carbon.

The highest adsorption for MB was from pineapple peel with 15 g of dosage for both size of activated carbon. As for 125 μm size, pineapple peel activated carbon recorded at 99.96% followed by 99.97% for size 355 μm. The highest adsorption value for MG was also from pineapple peel activated carbon with adsorption percentage 99.97% and 99.96% respectively for 355 μm and 125 μm size.

However, the effect of particle size did not give much significant impacts to the adsorption. It may be because of the surface area of the particle did not very much differ with each other. Overall this study showed that both MB and MG can be removed successfully by using pineapple waste activated carbon.

5.2 Recommendation

This study was to produce activated carbon from agricultural waste which were pineapple waste. Three parts of the pineapple, its crown, core and peel were chosen to be activated to remove MB and MG. From the study, it found out that activated carbon from pineapple peel was the highest in percentage removal of MB and MG. However, throughout this study several recommendations that can be taken into future consideration in order to further understanding of dye adsorption using activated carbon from pineapple waste.

First, the size of particle can be added more. From the experiment, it found out that the result on effect of particle size did not give much significant difference. In future consideration, the particle size can be varied with distinct size to get more significant value of removal. Secondly, characterization of activated carbon could be done to study about its surface morphology by using Scanning Electro Microscopic (SEM). The data on surface area can give an overview on its adsorption ability, thus can help the study to understand more.

The dye flow rate was controlled by burette manually. In future study, peristaltic pump could be used to reduce error during the experiment. The usage of this machine can help the consistency of dye to come in contact with the adsorbent before being filtered after that.

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APPENDIX A

Adsorbence value of Methylene Blue before and after treatment for adsorbent size 335 µm

Pineapple crown activated carbon

Table A1 : Adsorbance value of Methylene Blue before and after treatment for adsorbent size 335 µm

	5 g	15 g
Before (nm)	2.732	3.199
After (nm)	0.172	0.005

Pineapple core activated carbon

Table A2 : Adsorbance value of Methylene Blue before and after treatment for adsorbent size 335 µm

	5 g	15 g
Before (nm)	3.246	3.202
After (nm)	0.404	0.001

Pineapple peel activated carbon

Table A4 : Adsorbance value of Methylene Blue before and after treatment for adsorbent size 335 µm

	5 g	15 g
Before (nm)	3.305	3.209
After (nm)	0.003	0.001

APPENDIX B

Adsorbence value of Methylene Blue before and after treatment for adsorbent size 125 µm

Pineapple crown activated carbon

Table B1 : Adsorbance value of Methylene Blue before and after treatment for adsorbent size 125 µm

	5 g	15 g
Before (nm)	2,771	2.800
After (nm)	0.325	0.005

Pineapple core activated carbon

Table B2 : Adsorbance value of Methylene Blue before and after treatment for adsorbent size 125 µm

	5 g	15 g
Before (nm)	2.654	2.749
After (nm)	0.262	0.005

Pineapple peel activated carbon

Table B5 : Adsorbance value of Methylene Blue before and after treatment for adsorbent size 125 µm

	5 g	15 g
Before (nm)	2.668	2.666
After (nm)	0.004	0.001

APPENDIX C

Adsorbence value of Malachite Green before and after treatment for adsorbent size 335 µm

Pineapple crown activated carbon

Table C1 : Adsorbance value of Malachite Green before and after treatment for adsorbent size 335 µm

	5 g	15 g
Before (nm)	3.080	3.090
After (nm)	0.454	0.024

Pineapple core activated carbon

Table C2 : Adsorbance value of Malachite Green before and after treatment for adsorbent size 335 µm

	5 g	15 g
Before (nm)	3.117	3.111
After (nm)	0.072	0.032

Pineapple peel activated carbon

Table C6 : Adsorbance value of Malachite Green before and after treatment for adsorbent size 335 µm

	5 g	15 g
Before (nm)	3.117	3.119
After (nm)	0.007	0.001

APPENDIX D

Adsorbence value of Malachite Green before and after treatment for adsorbent size 125 µm

Pineapple crown activated carbon

Table D1 : Adsorbance value of Malachite Green before and after treatment for adsorbent size 125 µm

	5 g	15 g
Before (nm)	2.610	2.635
After (nm)	0.315	0.002

Pineapple core activated carbon

Table D2 : Adsorbance value of Malachite Green before and after treatment for adsorbent size 125 µm

	5 g	15 g
Before (nm)	2.654	2.749
After (nm)	0.262	0.005

Pineapple peel activated carbon

Table D7 : Adsorbance value of Malachite Green before and after treatment for adsorbent size 125 µm

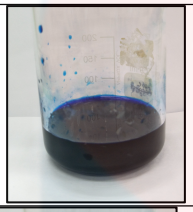
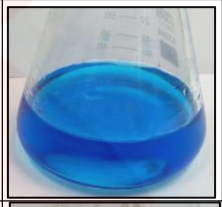
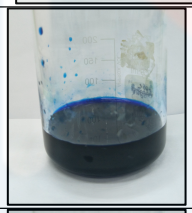
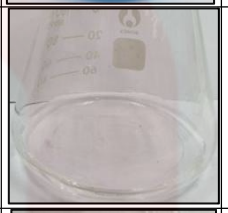
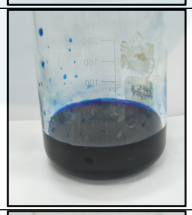
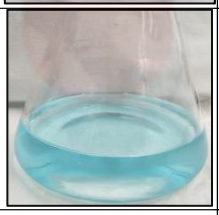
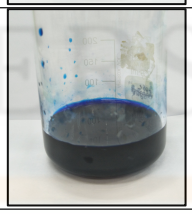
	5 g	15 g
Before (nm)	2.668	2.666
After (nm)	0.004	0.001

APPENDIX E

Observation on colour changes of Methylene Blue (MB) before and after treatment

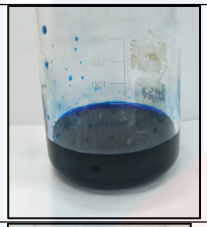
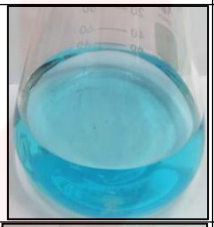
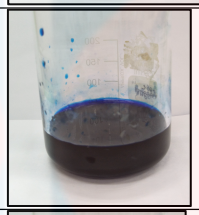
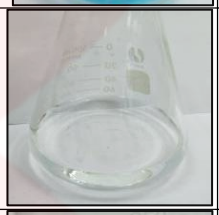
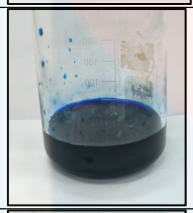
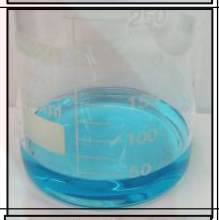
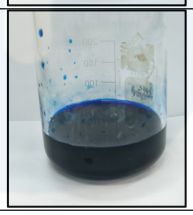
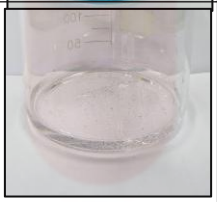
Pineapple crown activated carbon

Table E1 : Observation of MB colour before and after treatment (Pineapple crown activated carbon)

Activated carbon	Particle size (µm)	Dosage (g)	Colour of pure dye before treated	Colour of pure dye after treated	Observation
Pineapple crown	125	5			Blueish
		15			Clear
	355	5			Pale blue
		15			Clear

Pineapple core activated carbon

Table E2 : Observation of MB colour before and after treatment (Pineapple core activated carbon)

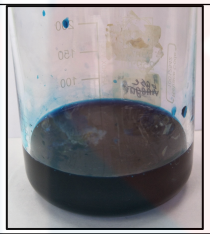
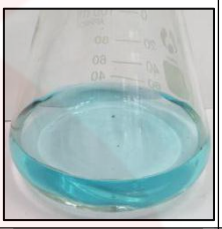
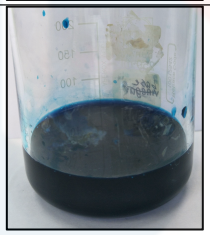
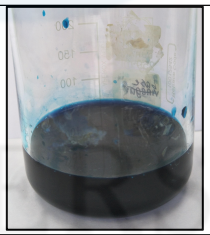
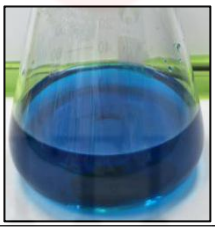
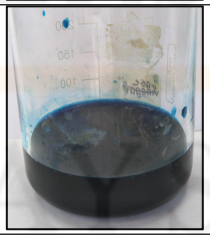
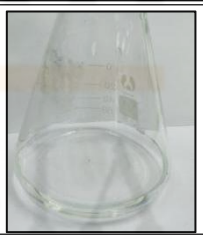
Activated carbon	Particle size (µm)	Dosage (g)	Colour of pure dye before treated	Colour of pure dye after treated	Observation
Pineapple core	125	5			Light blue
		15			Clear
	355	5			Light blue
		15			Clear

APPENDIX F

Observation on colour changes of Malachite Green (MG) before and after treatment

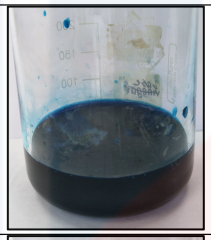
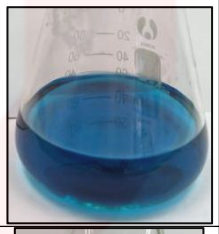
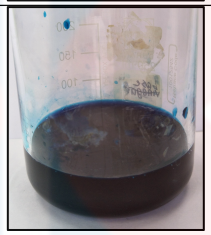
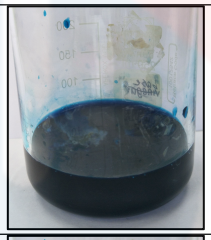
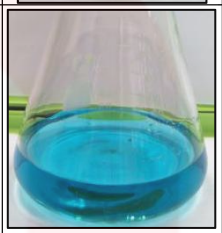
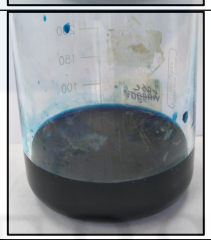
Pineapple crown activated carbon

Table F1 : Observation of MG colour before and after treatment (Pineapple crown activated carbon)

Activated carbon	Particle size (µm)	Dosage (g)	Colour of pure dye before treated	Colour of pure dye after treated	Observation
Pineapple crown	125	5			Very light greenish-blue
		15			Clear
	355	5			Greenish-blue
		15			Clear

Pineapple core activated carbon

Table F2 : Observation of MG colour before and after treatment (Pineapple core activated carbon)

Activated carbon	Particle size (µm)	Dosage (g)	Colour of pure dye before treated	Colour of pure dye after treated	Observation
Pineapple core	125	5			Greenish-blue
		15			Clear
	355	5			Light greenish-blue
		15			Clear