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JUDUL: Treatment of landfill leachate using activated carbon prepared from oil palm (Elaies Guineensis) shell

Ijazah: Sarjana Muda

SESI PENGAJIAN: 2002

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TREATMENT OF LANDFILL LEACHATES USING ACTIVATED CARBON PREPARED FROM OIL PALM (ELAIES GUINNESIS) SHELLS

HASNUL FAZLI BIN MD ZAIN

THIS DISSERTATION IS WRITTEN TO FULLFILL PART OF THE REQUIREMENT TO OBTAIN A BACHELOR DEGREE IN SCIENCE WITH HONOURS

PERPUSTAKAAN
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INDUSTRIAL CHEMISTRY
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DECLARATION

I declare that this is my own work with the exception that all short forms that sources for each of them are mentioned.

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ACKNOWLEDGEMENT

I would like to express my deepest gratitude to the supervisor of this research project, Mr. Collin Glen Joseph, for being such a wonderful individual in providing his guidance and thoughts towards this study. Without him, this research project much more difficult to be embarked and complete. His patience and time are much appreciated.

Secondly, I would like to thank all of our laboratory assistants Madam Zainab, Mr Muhin, Mr Sani, Mr Samudi and Mr Sani, for their corporation throughout the practical section of my project in the chemistry laboratory. Without them, my project would not be done successfully.

Last but not least, I would also like to thank my parents, family members and friends for giving me support throughout the period of this study. Their unconditional support serves as encourangement and motivation in helping me getting the study done within the given time frame.

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ABSTRACT

In this study, activated carbon was prepared from oil palm (*Elaeis Guinnesis*) shell through carbonization process at 200°C for 15 minutes and activation process at 500°C for 45 minutes by potassium hydroxide (KOH) as an activation agent. Characterization of activated carbon was carried out by studying its yield percent, moisture content, ash content, pH value, iodine number, methylene blue decolouring power, pores size and elemental study. Adsorption capacity of iron (Fe^{2+}), lead (Pb^{2+}) and cadmium (Cd^{2+}) metal ions contained in landfill leachate by activated carbon were also studied. Adsorption capacity value of Fe^{2+}, Pb^{2+} and Cd^{2+} were determined according to shaking time or contact time between 30 minutes to 150 minutes. The result showed that, as the concentration of KOH (w/w) increased from 0% to 25% the pH value was increased from 5.26 to 8.05, the iodine number was increased from 246.9mg/g to 466.1mg/g, the methylene blue decolouring power was increased from 2.045 mg/g to 3.273 mg/g and the moisture content was increased from 2.78% to 6.82%. In contrary, the ash content of activated carbon was decreased from 5.85% to 3.95% as the concentration of KOH (w/w) increased from 0% to 25%. On the other hand, the increment of KOH concentration has shown to yield higher percentage of activated carbon (from 33.0% to 57.6%) as well as its pore size and surface area. Elemental study showed that there were no Fe, Pb and Cd exist in the activated carbon. Furthermore, the study on adsorption capacity of metals ions contained in landfill leachate by activated carbon showed that the uptake of Fe^{2+} ion are between 0.077 ppm after 30 minutes to 0.428 ppm after 150 minutes, the uptake of Pb^{2+}ion are between 0.023 ppm after 30 minutes to 0.067 ppm after 120 minutes and the uptake of Cd^{2+} ion are between 0.002 ppm after 30 minutes to 0.009 ppm after 150 minutes.

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ABSTRAK

Dalam kajian ini, karbon teraktif telah disediakan daripada tempurung kelapa sawit (*Elaeis Guinnesis*) secara proses pengkarbonan pada 200° C selama 15 minit diikuti proses pengaktifan pada 500°C selama 45 minit dengan menggunakan potassium hidroksida (KOH) sebagai agen pengaktifan. Ciri-ciri karbon teraktif telah diambilkira dengan mengkaji peratus hasil, kandungan lembapan, kandungan abu, nilai pH, nombor iodin, kuasa penyahwarnaan metilina biru, saiz liang dan kajian unsur-unsur. Kapasiti penjerapan ion-ion ferum (Fe^{2+}), plumbum (Pb^{2+}) and kadmium (Cd^{2+}) yang terkandung di dalam air kurasan dari tapak pelupusan oleh karbon teraktif juga dikaji. Nilai kapasiti penjerapan terhadap Fe^{2+}, Pb^{2+} and Cd^{2+} ditentukan berdasarkan masa goncangan atau masa sentuhan di antara 30 minit hingga 150 minit. Keputusan menunjukkan bahawa, dengan kepekatan KOH (w/w) meningkat dari 0% ke 25%, nilai pH telah meningkat dari 5.26 hingga 8.05, nombor iodin telah meningkat dari 246.9mg/g hingga 466.1mg/g, kuasa penyahwarnaan metilina biru telah meningkat dari 2.045 mg/g hingga 3.273 mg/g dan kandungan lembapan telah meningkat dari 2.78% hingga 6.82%. Sebagai perbezaan, kandungan abu karbon teraktif telah menurun dari 5.85% hingga 3.95% dengan peningkatan kepekatan KOH (w/w) dari 0% ke 25%. Selain dari itu, peningkatan kepekatan KOH telah menunjukkan penghasilan peratus hasil yang lebih tinggi (dari 33.0% hingga 57.6%) dan sama juga bagi saiz liang dan luas permukaan. Kajian unsur menunjukkan bahawa unsur Fe, Pb dan Cd tidak wujud di dalam karbon aktif. Tambahan lagi, kajian ke atas kapasiti penjerapan ion-ion logam yang terkandung di dalam air kurasan dari tapak pelupusan oleh karbon teraktif menunjukkan pengambilan ion Fe^{2+} adalah di antara 0.077 ppm selepas 30 minit hingga 0.428 ppm selepas 150 minit, pengambilan ion Pb^{2+} adalah di antara 0.023 ppm selepas 30 minit hingga 0.067 ppm selepas 120 minit dan pengambilan ion Cd^{2+} adalah diantara 0.002 ppm selepas 30 minit hingga 0.009 ppm selepas 150 minit.

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LIST OF SYMBOLS / ABBREVIATION

% KOH (w/w)	Amount KOH per amount activated carbon
%	Percentage
g	Gram
h	Hour
K_2CO_3	Potassium Carbonate
KOH	Potassium Hydroxide
L	Liter
ml	Milliliter
NaS_2O_3	Sodium thiosulphate
^oC	Celsius degree
ppm	Part per million
S1	Physically activated carbon
S2	Chemically activated carbon prepared by impregnation of 5% KOH(w/w)
S3	Chemically activated carbon prepared by impregnation of 9% KOH(w/w)
S4	Chemically activated carbon prepared by impregnation of 15% KOH(w/w)
S5	Chemically activated carbon prepared by impregnation of 20% KOH(w/w)
S6	Chemically activated carbon prepared by impregnation of 25% KOH(w/w)

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CHAPTER 1

INTRODUCTION

1.1 LANDFILL LEACHATES

Landfill leachate is a highly complex polluted wastewater from breakdown of solid waste. Leachate pollution is the result of physical, chemical and biological processes in landfill combined with landfill water regime, weather conditions, waste composition and underlying soil (El-Fadel *et al.*, 1997). Industries creating "hazardous wastes" (as legally defined under federal law) may not send those wastes to municipal landfills, but must instead send them to special hazardous waste landfills.

Leachates contains a wide variety of potential carcinogens and potentially toxic chemical that represent a threat to public health. In addition, leachate also contains high concentrations of toxic organic, sulfate, phosphorus, ammonia, heavy metals and high alkalinity. It was known that small amounts of groundwater and will render it unsuitable for use as domestic water supply. As a result, it is important to prevent the dispersion of these toxic compounds to ground and surface waters. Also, it is important to reduce or remove the presence of these contaminants to lower the possibility of their uptake by plants where they might be accumulated in the food chain (Lin *et al.*, 2001).

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1.2 TREATMENT OF LANDFILL LEACHATE

Activated Carbon was first used to treat water over 2000 years ago. It was produced commercially at the beginning of the 20th century and was only available in powder form at that time. Initially activated carbon was mainly used to decolorize sugar and then from 1930 for water treatment to remove taste and odor. Granular activated carbon was first developed as a consequence of World War I for gas masks and has been used widely for water treatment, solvent recovery and air purification. The unique structure of activated carbon produces a very large surface area for adsorption. Activated carbon can be produced from a variety of carbonaceous raw material, such as oil palm shells, coal, coconut shells, peat, wood sawdust, lignite, olive stones, petroleum residues and lignite. Different precursors will give different types of activated carbon (Helena *et al.*, 1991).

Activated carbon with its very great surface area and pore volume is hundreds of times more efficient than charcoal and at least 40 times more than bone black. The specific surface area ranges from 300 to 2500 m^2/g. The major uses of activated carbon is in solution purification, such as the cleanup of cane, beet, and corn sugar solutions, and for the removal of tastes and odours from water supplies, vegetable and animal fats and oils, alcoholic beverages, chemicals, and pharmaceuticals. The recovery of streptomycin represents a typical application of the continuous treatment of liquids. The vapor adsorbent type of activated carbon was first used in gas masks and now widely employed in both military and industrial gas masks (George, 1984).

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Activated carbon is used in air conditioning systems to control odours in large restaurants, auditoriums, and airport concourses. An important field of application is the industrial recovery and control of vapors. The recovery of such vapors amounts to millions of kilograms per year, with a recovered value of several hundred million dollars. Activated carbon is able to adsorb practically any organic solvent at about 35°C and release it when heated to 120°C or higher for solvent recovery. One of the largest uses is for gasoline vapor emission control canisters in automobiles. Special impregnated grades are used in cigarettes filters. Activated carbon can now be made in an extruded form, which in vapor adsorbing presents only about half the air resistant of the older granulated heterogeneous powder. The pressure drop through carbon, whether pellet or granular, depends primarily on the average particle size. Pelleted material ensures more uniform packing, hence more even distribution of air flow (Browning, 1972).

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1.3 RESEARCH OBJECTIVE

The objective of this research are :

a. To prepare activated carbon from oil palm shell using KOH as a dehydrating agent.

b. To physically and chemically characterize and obtain fundamental data of the prepared activated carbon.

c. To Evaluate the ability of the prepared activated carbon to adsorbed pollutants (Fe, Pb, and Cd metals) ; including time dependence parameter.

1.4 SCOPE OF RESEARCH

The study focuses only on the preparation of activated carbon by oil palm shells as a raw material using KOH as an activating agent. The activated carbon produced used for treatment of landfill leachates by removal of metals ion (iron, lead and cadmium). Landfill leachate used for this study was obtained from Solid Wastes Procession Site at Kayu Madang, Tuaran, Sabah.

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CHAPTER 2

LITERATURE REVIEW

2.1 LANDFILL LEACHATE

One of the most important problems with designing and maintaining a landfill is managing the leachate that is generated when water passes through the waste. The leachate consists of many different organic and inorganic compounds that may be either dissolved or suspended. Regardless of the nature of the compounds, they pose a potential pollution problem for local ground and surface waters. Many factors influence the production and composition of leachate. One major factor is the climate of the landfill. For example, where the climate is prone to higher levels of precipitation there will be more water entering the landfill and therefore more leachate generated. Another factor is the site topography of the landfill which influences the runoff patterns and again the water balance within the site. Leachates arising from the percolation of water through sanitary landfills typically have significant polluting potentials (Ronald, 2000).

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2.2 ATOMIC ABSORBANCE SPECTROPHOTOMETER (AAS)

Atomic-absorption spectroscopy (AAS) uses the absorption of light to measure the concentration of gas-phase atoms. Since samples are usually liquids or solids, the analyte atoms or ions must be vaporized in a flame or graphite furnace. The atoms absorb ultraviolet or visible light and make transitions to higher electronic energy levels. The analyte concentration is determined from the amount of absorption. Applying the Beer-Lambert law directly in AA spectroscopy is difficult due to variations in the atomization efficiency from the sample matrix, and nonuniformity of concentration and path length of analyte atoms (in graphite furnace AA). Concentration measurements are usually determined from a working curve after calibrating the instrument with standards of known concentration (Strobel and William, 1989). Figure 2.1 shows the schematic diagram of atomic absorbance spectrometer (AAS).

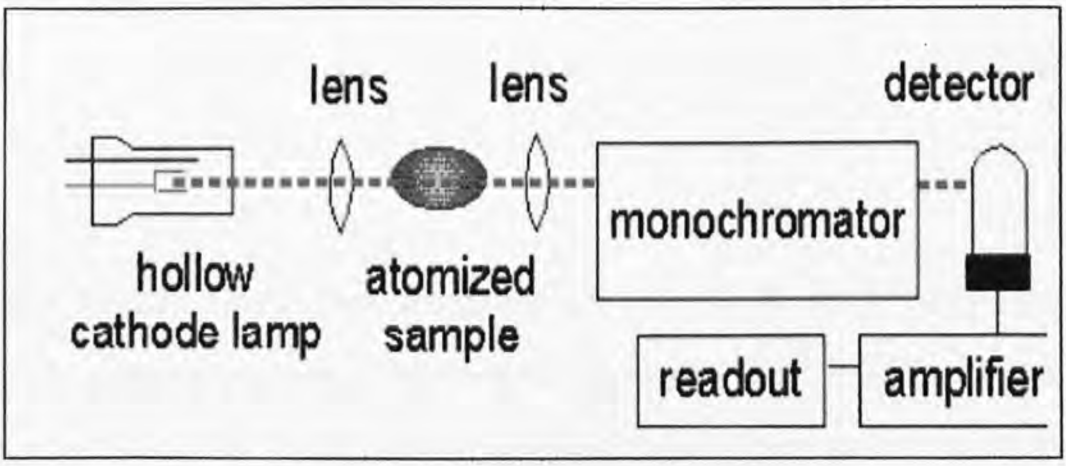

Figure 2.1 Schematic Diagram of Atomic Absorbance Spectrometer (AAS)

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2.3 METALS

2.3.1 Introduction

Chemically, metals are classified as elements which tend to lose electrons in a chemical reaction. As solids, they have easily movable electrons, which make them good conductors of electricity and reflectors of light. In compounds, they tend to be positively charged, because they have lost electrons (which carry a negative charge), and they tend to bind with non-metals. This tendency makes some of them, such as iron and magnesium, biologically useful as part of biochemically active compounds like enzymes. Others, such as lead, cadmium, and mercury are highly toxic because they interfere with the normal operation of these biological compounds (Schroder, 1990).

2.3.2 Targeted Metals Adsorption

a. Iron (Fe)

Iron is lustrous, metallic, greyish tinge and it is found in the sun and many types of stars in considerable quantity. Iron nuclei are very stable. Iron is a vital constituent of plant and animal life, and is the key component of haemoglobin. Iron is the most used of all the metals, comprising 95 percent of all the metal tonnage produced worldwide. Its combination of low cost and high strength make it indispensable, especially in applications like automobiles, the hulls of large ships, and structural components for buildings. Iron (III) oxides are used in the production of magnetic storage in

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computers. They are often mixed with other compounds, and retain their magnetic properties in solution (Teh, 1999).

Excessive dietary iron is toxic, because excess ferrous iron reacts with peroxides in the body, producing free radicals. When iron is in normal quantity, the body's own antioxidant mechanisms can control this process. In excess, uncontrollable quantities of free radicals are produced. The lethal dose of iron in a two year old is about three grams of iron. One gram can induce severe poisoning. There are reported cases of children being poisoned by consuming between 10-50 tablets of ferrous sulfate over a few hour period. Overconsumption of iron is the single highest cause of death in children by unintentional ingestion of pharmaceuticals. The DRI (Dietary_Reference_Intake) lists the Tolerable Upper Intake Level (UL) for adults as 45 mg/day. For children under fourteen years old the UL is 40 mg/day. If iron intake is excessive a number of iron overload disorders can result, such as hemochromatosis. For this reason, people shouldn't take iron supplements unless they suffer from iron deficiency and have consulted a doctor. Blood donors are at special risk of low iron levels and are often recommended to supplement their iron intake (Ronald *et al*., 2000).

b. Lead (Pb)

Lead is a bluish-white lustrous metal. It is very soft, highly malleable, ductile, and a relatively poor conductor of electricity. It is very resistant to corrosion but tarnishes upon exposure to air. Lead is a chemical element in the periodic table that has the symbol Pb (Plumbum) and atomic number 82. A soft, heavy, toxic and malleable poor

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metal, lead has a dull gray appearance and is bluish white when freshly cut but tarnishes to dull gray when exposed to air. Lead is used in building construction, lead-acid batteries, bullets and shot, and is part of solder, pewter, and fusible alloys. Lead has the highest atomic number of all stable elements (Teh, 1999).

Lead is a poisonous metal that can damage nervous connections (especially in young children) and cause blood and brain disorders. Long term exposure to lead or its salts (especially soluble salts or the strong oxidant PbO_2) can cause nephropathy, and colic-like abdominal pains. Its historical use by the Roman Empire for water piping (and its salt, lead acetate, also known as *sugar of lead*, as a sweetener for wine) is considered by some to be the cause for the dementia that affected many of the Roman Emperors. The concern about lead's role in mental retardation in children has brought about widespread reduction in its use (lead exposure has been linked to schizophrenia. Paint containing lead has been withdrawn from sale in industralised countries, though many older houses may still contain substantial lead in their old paint. It is generally recommended that old paint should not be stripped by sanding, as this generates inhalable dust. Lead salts used in pottery glazes have on occasion caused poisoning, when acid drinks, such as fruit juices, have leached lead ions out of the glaze. It has been suggested that what was known as "Devon colic" arose from the use of lead-lined presses to extract apple juice in the manufacture of cider. Lead is considered to have particularly nasty consequences for girls and young women. For that reason many universities do not hand out lead-containing samples to girls for instructional laboratory analyses. The earliest pencils actually used lead, though pencil leads have been made for the last couple of centuries from graphite, a naturally occurring form (allotrope) of carbon (Faust and Aly, 1986).

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