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Adsorption of manganese in waste water treatment using banana peels

by

Muhammad bin Harith
10800

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

SEPT 2011

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CERTIFICATION OF APPROVAL

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CERTIFICATION OF ORIGINALITY

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

ΛUHAMMAD BIN HARITH)

ABSTRACT

[anganese metal is seen as one of the biggest contributor to water pollution in the planet. lthough there exist conventional technologies to remove heavy metal from water, it is either neconomical or ineffective. Adsorption is seen as a good solution to the current problem and ith wide abundance of banana peels available in Malaysia which makes it cheap, the problem : heavy metal pollution are hope to be reduced. This would add value to the agricultural ommodities. This project aims to find a method to develop the most efficient adsorbent from anana peels. In the project, the banana peels is initially dried, grinded and extraction study was one to determine the adsorption capacity. Development of the banana peels characteristics is one using CHN Elemental Analyzer and FTIR. The adsorption study was done at different ontact time, different dosage and also different manganese concentration at constant room mperature. The final result obtained shows that the banana peels has the potential to be turn ito an efficient adsorbent in adsorption of manganese.

ACKNOWLEDGEMENT

lory be to Allah, the most compassionate and the most merciful for giving me the strength and portunity to finish this project and blessed be the Prophet s.a.w., his family and his companion r showing us the way to achieve paradise.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Background of Study

Removal of heavy metals from industrial wasterwater is of primary importance because they do not only cause contamination of water but are also toxic to many life forms. Furthermore, they can accumulate in the food chain possibly causing severe danger to human health. Since most of heavy metals are non-degradable and toxic (Calace et al., 2002), so the realistic option is by reducing the concentration to acceptable levels before discharging them into the environment. Otherwise, these toxic metals would case a threat to the public health. Some of the most dangerous metals concerned are zinc, chromium, iron, nickel and mercury, cadmium and lead (Kadirvelu et al., 2001).

This study concerned with adsorbing manganese as a method to remove the metal ion from the wastewater. Most manganese enters the environment as a result of human activities such as mining, purifying, lead and cadmium ores, steel production, coal burning, galvanizing and form wastewater of pharmaceuticals, paints, pigments, insecticides cosmetics and industries (A.K. Bhattacharya 2006). Technologies generally used for the removal of heavy metals such as ion exchange, chemical precipitation, ultra-filtration, reverse osmosis and electrochemical dispersion but all of these method do not seem to be highly feasible due to their high cost (Axtell et al., 2003). As a result, recent development has focused of more cost effective alternatives.

Adsorption is one of the physic-chemical treatment process found to be effective in removing heavy metals from aqueous solution using low cost adsorption (Bailey et al., 1999). Adsorption of heavy metal ion is widely used as a unit operation in the treatment of industrial wastewater. Most commonly used adsorbents are untreated plants wastes such as tea leaf powder (King et al., 2006), rubber leaf powder (Hanafiah, 2006), papaya wood (Saeed et al., 2005), newspaper pulp (Chakravarthy et al., 2007) etc. The type of adsorbent is determined by their adsorption capacity, regeneration characteristics and physical properties of subsequent product.

Adsorption is the process of accumulating substances that are in solution on a suitable interface (Metcalf and Eddy, 2004). The adsorption of heavy metal is widely studied throughout the globe in order to enhance the treatment process of wastewater. In a continuing search for the adsorbent, various lignocellulosic materials or agricultural waste such as coconut shell, rice husks, saw dust and wheat straw were used (Srivastasa et al.,1987). These materials were pyrolysed or carbonized in an inert atmosphere in order to remove volatile organic constituent, leaving behind a highly porous carbonaceous residue, followed by either chemical, steam or gas activation for removal of the pollutant. The presence of heavy metals in the wastewater is due to the industrial processes such as coating of metal surfaces in the electroplating industry and leather tanning.

Natural resources that are available in the form of waste from agricultural operations might be used as low cost adsorbent. A number of adsorbent materials have been studied for their capacity to remove heavy metals including activated carbon, activated alumina, ion exchange resins, crushed coals etc. (Muhammad et al., 1998). Adsorption by natural waste likes banana peels is assumed to be one of the best adsorbent based on their characteristic that we will see in this research later.

1.2 Problem Statements

The presence of heavy metals in wastewater causes harm when released to the atmosphere since they are classified as toxic. The wastewater which contaminated with heavy metal could seep through the groundwater sources and contaminating stream flow. According to the (World Health Organization, 1984) the metals of most immediate concern are cadmium, chromium, cobalt copper, lead, nickel, mercury and zinc. Since stream flow is a prime meter water source in Malaysia, hence it will affect human's health during water consumption especially drinking. The abundance of agricultural of biomass also creates problems of disposing it.

Due to the ineffective or expensive cost of current wastewater treatment, researchers are currently finding a low cost method that can remove the heavy metal from the water. The new method should focus on using by-product that are cheap and abundance in developing countries. Using adsorption technique with alternative adsorbent is chosen in this research to remove heavy metals. We will use banana peels as adsorbent and manganese as the heavy metals because based on Environmental Quality Act 1974; concentration of manganese in Malaysia waste water is quite high.

1.3 Objectives and Scope of Study

The main objective of this research is to study the capability of banana peels to be the alternative adsorbent in adsorbing manganese as the heavy metals. We will run several analyses to study the characteristic of banana peels.

Second objective of this research is to study the contact time between banana peels and manganese concentration. We should find what the contact time to reach the equilibrium is.

Besides, we also want to study the influence of modified adsorbent dosage which is banana peels in this research for removing heavy metals. Different concentration of heavy metals might need different dosages.

Adsorption isotherm also is very important. This research would analyze adsorption isotherms for every adsorption model. Hence, the adsorption capacity would be identified clearly from derived variables in the isotherm. So, we can summarize that there are four objectives of this research which are:

- To study the capability of banana peels as an adsorbent to adsorb Manganese.
- To study the effect of contact time on adsorption activities.
- To study the effect of adsorbent dosage on adsorption activities.
- To study the effect of Manganese concentration on adsorption activities.
- To study the isotherm model for the adsorption activities.

CHAPTER 2

LITERATURE REVIEW

2.1 Heavy Metals

A heavy metal is a member of a loosely-defined subset of elements that exhibit metallic properties. It mainly includes the transition metals, some metalloids, lanthanides, and actinides. Heavy metal can include elements lighter than carbon and can exclude some of the heaviest metals. Heavy metals occur naturally in the ecosystem with large variations in concentration.

2.1.1 Heavy Metals Contamination

Heavy metals contamination is one of the major issues in wastewater treatment process. Since several types of heavy metal are classified as toxic, hence the removal of heavy metal shall be a must in any wastewater treatment process. Generally, the contamination of heavy metals in wastewater is from industrial activity. According to (Rahman et al, 2000), the effluent from metal finishing process may contain up to 10 mg/L of copper, chromium, nickel and zinc.

Electroplating, leather tanning, cement dyeing, metal processing, and wood preservatives contribute to the contamination of heavy metals in streams and major drains (Nomanbhay et al, 2004). Even worst, it can penetrate into the ground and seep through the ground water sources. Thus, the hazard of toxicity is exposed to the human since the streamflow is the prime source of water supply in Malaysia.

There are several applications of heavy metal removal in wastewater treatment process (Huang et al., 1989). Some might be expensive and create drawbacks. The applications are precipitation, ion exchange, Reverse Osmosis (RO), electrodialysis, and adsorption.

Precipitation causes problem due to the sludge production. The precipitation is basically done by coagulation process. Disposal of sludge needs a good planning which will consume an expensive budget. Ion exchange is also an expensive method. It is classified as tertiary treatment. Modern facilities meant for removal of heavy metals in ion exchange need to be installed.

Furthermore, ion exchange is site specific. Adsorption process is found as a very practical approach to remove heavy metals. There is a wide range of adsorbent that can be found applied in wastewater treatment process. Heavy metal adsorption by using activated carbon is one of those. The existence of some functional groups might be associated with the capability of carbon to adsorb heavy metals. However, it is only a part of adsorption theory.

2.1.2 Impact of Heavy Metals

Many metallic elements play important roles in the function of living organisms. Living organism require trace amount of some heavy metals including cobalt, copper, iron, manganese, molybdenum, vanadium, strontium and zinc. They not only constitute a nutritional requirement, but also a physiological role. However, overabundance of the essential elements and their substitution by nonessential ones can cause toxicity symptoms (Kenish, 1992). Non-essential heavy metals of particular concern to surface water systems are cadmium, chromium, mercury, lead, arsenic and antimony. Assimilation of metals takes place in the microbial world as well in plants, these elements tend to get concentrated as they progress through the food chain. Excessive amounts of a metal species along this route lead to toxicity symptoms, to disorder in cellular functions and death (Volesky, 1990)

2.1.3 Removal Mechanism

Heavy metal removal could only happen under several phenomenons which are physical adsorption, chemisorptions, hydrogen bonding, ion exchange, surface precipitation and filtration. Physical adsorption is the most common application in removing heavy metals and it is recognized as primary removal mechanism for organic adsorbates.

Chemisorption behaves more specific by involving the formation of covalent bond (electron sharing) between adsorbate and the carbon surface. Chemisorption is considered to be irreversible while physical adsorption is reversible. A long-range attractive force between the hydrogen atom of hydrated metal ions and a specific carbon surface site enable the adsorption to be happened. Hydrogen bond can be classified under chemisorptions. However, covalent bonding is much stronger than hydrogen bond. Covalent bond is responsible to form a much stronger inner-shape complex while hydrogen bonding will form outer-shape complex. Ion exchange occurs when adsorbent and adsorbate posses opposite charges. Precipitation of metals on a surface is much easier than the formation of the same solid in solution. High concentration of metals and OH- in carbon pore volume can enhance metal removal.

2.1.4 Natural adsorbent

An alternative for removal of heavy metals instead of using the high cost technology and material is by using a natural adsorbent likes a banana peel which is a solid waste. Banana peel is believed to be a suitable as biosorbent due to its easy availability and high sorption capacity of heavy metals due to the presence of functional groups like -COOH, -OH, esters and amines.

2.2 Adsorption

Adsorption process is found as a very practical approach to remove heavy metals. There is a wide range of adsorbent that can be found applied in wastewater treatment process. Heavy metal adsorption by using activated carbon is one of those. The existence of some functional groups might be associated with the capability of carbon to adsorb heavy metals. However, it is only part of adsorption theory.

Adsorption is defined as a process of collecting substances in water onto a surface of solid. Another extended definition of adsorption is the process of accumulating substances that are in solution on a suitable interface (Metcalf and Eddy, 2004). When a liquid mixture is in contact with a microporous solid, adsorption of certain components in the mixture takes place on the internal surface of the solid. There are several factors that affect the efficiency of adsorption.

There are two major processes happen during adsorption. Firstly is physiosorption and secondly is chemisorptions. The functional group which has high affinity to metals will adsorb the metal during physiosorption. The physiosorption will last until the equilibrium state. Time taken until the equilibrium state is called equilibrium time (t_e) and the concentration at t_e is called equilibrium concentration (C_e). The residual metal concentration which is not adsorbed during physiosorption will be adsorbed by chemisorptions process. The chemisorptions process can be described as the intrapore diffusion of heavy metals into carbon molecule. This process is time consuming since its adsorption rate is relatively small.

There are some modification methods applicable in activating the carbon surface. The modification method can be physically and chemically. Typically, in physical modification, the carbon will heated up until 750 ^oC however, with an insufficient supply of oxygen to sustain combustion. Then it is exposed to oxidizing gas such as steam and CO_2 at high temperature in the range from 800 to 900 ^oC. Second method of activation is by using chemicals. Formaldehyde, nitric acid (HNO_3) and pH controlled solution which is combination of sulphuric acid (H_2SO_4) and sodium hydroxide (NaOH) are always used in chemical activation treatment. Typically, strong acid will be used in chemical treatment of carbon activation.

2.2.1 Adsorption Isotherm

In developing the adsorption isotherm, the quantity of adsorbate that can be taken up by an adsorbent is a function of both the characteristics and concentration of adsorbate and the temperature. Generally, the amount of material absorbed is determined as a function of the concentration at a constant temperature, and the resulting function is called an adsorption isotherm (Metcalf and Eddy, 2004)

Equation that are often used to describe the experimental isotherm data were developed by Freundlich, Langmuir, and Brunauer, Emmet, and Teller (BET isotherm) (Shaw 1966). One of the three which is the Freundlich isotherm is used most commonly to describe the adsorption characteristics of the activated carbon used in water and wastewater treatment. Derived empirically in 1912, the Freundlich isotherm is defined as below:

$$x/m = K_f C_e^{1/n} \qquad \text{(eq. 1)}$$

where x/m = mass of adsorbate adsorbed per unit mass of adsorbent, mg adsorbate/ g activated carbon.

K_f = Freundlich capacity factor, (mg adsorbate/ g activated carbon) (L water/mg adsorbate)$^{1/n}$

C_e = equilibrium concentration of adsorbate in solution after adsorption, mg/L

1/n = Freundlich intensity parameter

In 1916, Irving Langmuir published a new model isotherm for gases adsorbed to solids, which retained his name. It is a semi-empirical isotherm derived from a proposed kinetic mechanism. It is based on four assumptions:

- The surface of the adsorbent is uniform, that is, all the adsorption sites are equivalent.
- Adsorbed molecules do not interact.
- All adsorption occurs through the same mechanism.
- At the maximum adsorption, only a monolayer is formed: molecules of adsorbate do not deposit on other, already adsorbed, molecules of adsorbate, only on the free surface of the adsorbent

The constant can be written as:

$$\log (x/m) = \log K_f + 1/n \log C_e \qquad \text{(eq. 2)}$$

Derived from rational consideration, the Langmuir adsorption isotherm is defined as:

$$x/m = abC_e / (1+bC_e)$$

where x/m = mass of adsorbate adsorbed per unit mass of adsorbent, mg adsorbate/ g banana peels.

a, b = empirical constant

C_e = equilibrium concentration of adsorbate in solution after adsorption, mg/L

CHAPTER 3

RESEARCH METHODOLOGY

3.0 PROJECT ACTIVITIES

3.1 Experiment Procedures: Preparation of minced banana peels

The banana peels were obtained from a local market in Seri Iskandar, Perak. The peels were first washed with water (more than 5 times) to remove any adhering dirt of moisture. They were then dried in an oven at temperature (50°C) for 48 hour. After that the dried banana peels being grind to form particles approximately about 0.8 to 2 mm in size.

Figure 1. Drying banana peels in oven

Figure 2. Dried banana peels

Figure 3. Grinding in ball pulverisette

Figure 4. 0.8 – 2 mm banana peels

3.2 Preparation of manganese solution

Given the MW_{MnSO4} = 169.01 g/mol.

MW_{Mn} = 54.938 g /mol

Using 3.076 g of MnSO4 = 1000ppm

Using $M_1V_1 = M_2V_2$ formula, 5 different concentration of MnSO4 (from the 1000 ppm) are produce which are 10,20,30,40 and 50 ppm.

Figure 5: Manganese solution

3.3 Surface characteristic test for banana peels

The banana peels surface was characterized by diffuse reflectance infrared Fourier Transform Infra-Red (DRIFT) using a spectrometer using 200 scans, resolution of 4 cm-1, and ambient atmosphere. In this procedure, a crucible, used in a reflectance apparatus, was filled with the banana peels particles without dilution. Specific surface area and pore size distribution were determined with 2.0 g of minced banana peel. Besides FTIR, the sample also was analysed by using CHN analyser to determine the composition of carbon, nitrogen and hydrogen in the sample

3.4 Batch Adsorption Studies

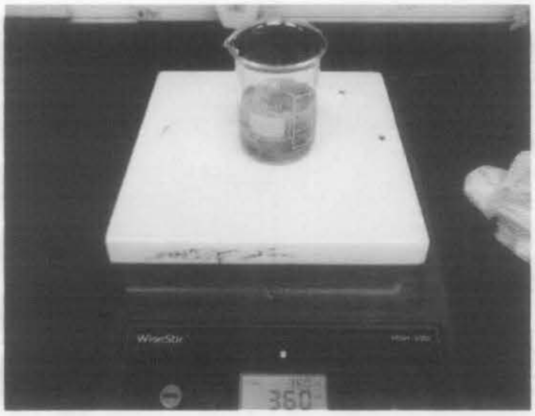

Figure 6: Batch experiment using magnetic stirrer

The adsorption of Mn^{2+} was investigated in batch equilibrium experiments. Stock solutions of manganese ions (1.0 g/L) were prepared using the obtained standard solution, in distilled water. There are 3 experiments that we had run for this research which are stated below:

3.4.1 Test for contact time

250 ml of Erlenmeyer flasks with 100 ml of adsorbate (Mn) solution were prepared with initial concentration of 20ppm. 2.0g of adsorbent (banana peels) was measured and added to the flask. The flasks were then agitated at 360 rpm using magnetic stirrer. They were removed from the shaker for residual adsorbate analysis one after another at 15, 30, 45, 60, 75, 90, 105, 120 minutes. The samples were filtered and the final adsorbate concentrations were measured.

3.4.2 Test for adsorbent dosage

250 ml of Erlenmeyer flasks with 100 ml of adsorbate (Mn) solution were prepared with initial concentration of 20ppm. 0.5g, 1.0g, 1.5g, 2.0 and 2.5g of adsorbent (banana peels) was measured and added each of the conical flasks. The flasks were then agitated at 360 rpm using magnetic stirrer. They were removed from the shaker for residual adsorbate analysis after 120 minutes. The samples were filtered and the final adsorbate concentrations were measured.

3.4.3 Test for different manganese concentration

250 ml of Erlenmeyer flasks with 100 ml of adsorbate (Mn) solution were prepared with initial concentration of 10ppm, 20ppm, 30ppm, 40ppm and 50ppm. 2.0g of adsorbent (banana peels) was measured and added each of the conical flasks. The flasks were then agitated at 360 rpm using magnetic stirrer. They were removed from the shaker for residual adsorbate analysis after 120 minutes. The samples were filtered and the final adsorbate concentrations were measured.

3.4.4 AAS Analysis

All of the filtered test tubes were then analyzed using AAS to check the Mn2+ concentration. Graphs were plotted to observe the effect of parameters varied on the adsorption activities.

3.5 Key Milestone and Gantt Chart

	PROJECT PLANNING	WEEK NO													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	ACTIVITIES														
1	Finalize materials and equipments available							mid sem breaks							
2	Finalize Methodology														
3	Preparation of Dried Minced Banana Peels														
4	Banana Peels Analysis														
5	Adsorption study of banana peels														
7	EDX														
8	Submussion of Progress Report														
9	Submussion of Final Report and Seminar														

Figure 7: Gantt Chart

3.6 List of Equipment and Chemicals

1. Atomic Adsorption Spectrophometer (AAS)
2. Ball Pulverisette Grinder
3. Oven
4. CHN Analyzer
5. Fourier Transform Infrared Spectroscopy (FTIR)
6. Manganese sulfate ($MnSO_4$)
7. Distilled water

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Banana Peels Analysis

4.1.1 FT-IR Analysis

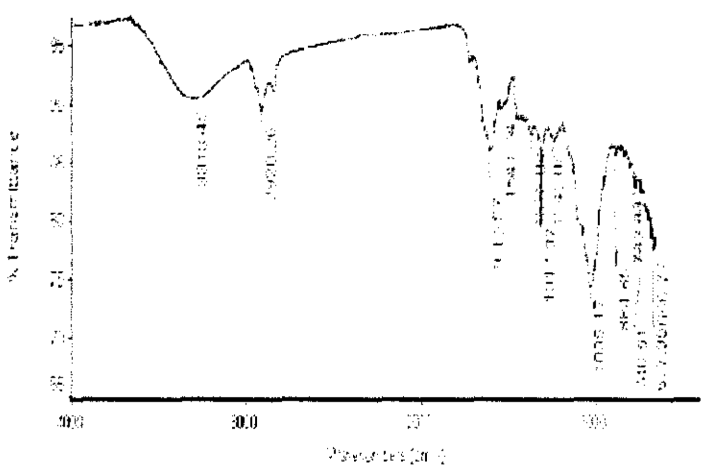

Figure 8: FT-IR of banana peels

FT-IR spectra of banana peel were obtained in order to understand the nature of the functional groups present in banana peel. FT-IR spectra (Figure X) displayed a number of peaks, indicating the complex nature of the adsorbent. Bands appearing at 3313.4, 2920.3, 2850.6, 1734, 1613.6, 1317.4, 1035.2 and 884.6 cm^{-1} in the figure were assigned to OH stretching, C-H stretching of alkane, C-H and C=O stretching of carboxylic acid of ester, COO- anion stretching, OH bending, C-O stretching of ester or ether and N-H deformation of amines respectively. Out of these, carboxylic and hydroxyl groups played a major role in the adsorption of Mn^{2+} ions.

The presence of carboxyl and hydroxyl groups was confirmed by FT-IR spectra. FT-IR spectra of banana peel led to the conclusion that the peaks corresponding to carboxyl and hydroxyl groups were well resolved in the case of banana peel cellulose.

4.1.2 CHN Analysis

Using CHNS Analyzer, we get the composition of banana peels as stated in table below:

Table 1: CHN compostion of banana peels

		C	H	N
Banana peels	1	39.05	4.501	1.889
	2	40.63	4.732	1.814
	Avg	**39.84**	**4.617**	**1.852**

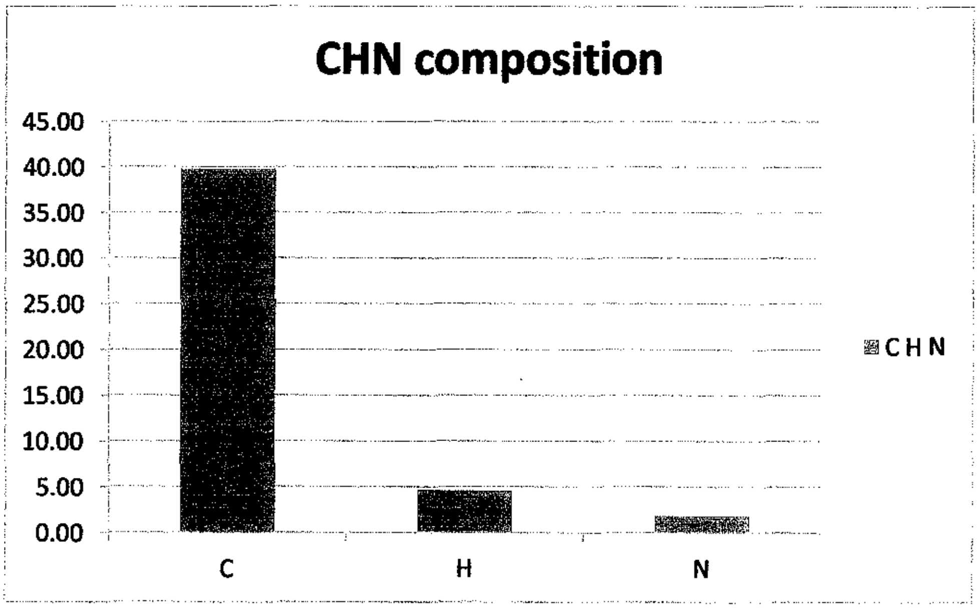

Figure 9: Graph of CHN composition

4.1.3 AAS Analysis

- Test for contact time:

Table 2: Experiment of contact time

Contact time (min)	Residue conc. (ppm), C_t	Initial conc. (ppm), C_o	Weight of adsorbent (g), m	Volume of solution (L), V	% Mn removal	Adsorption capacity
0	20	20	2	0.1	0	0
15	16	20	2	0.1	20	0.2
30	12	20	2	0.1	40	0.4
45	2	20	2	0.1	90	0.9
60	0.98	20	2	0.1	95.1	0.951
75	0.9	20	2	0.1	95.5	0.955
90	0.8	20	2	0.1	96	0.96
105	0.75	20	2	0.1	96.25	0.9625
120	0.7	20	2	0.1	96.5	0.965

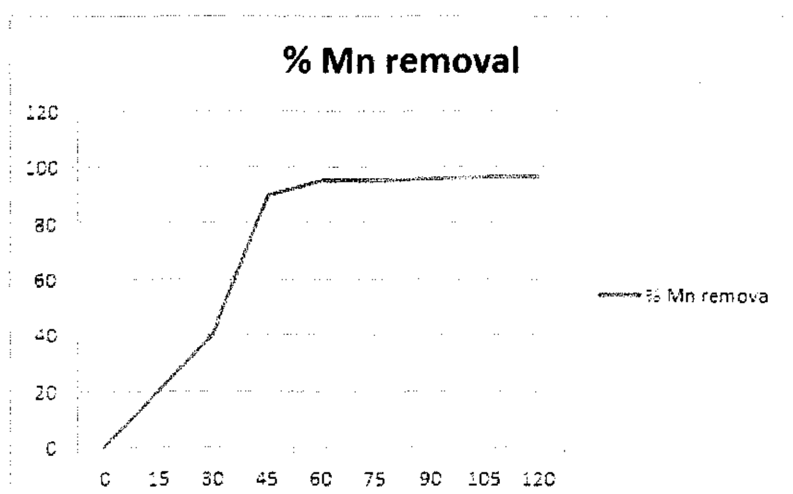

Figure 10: Graph of % of Mn removal vs contact time

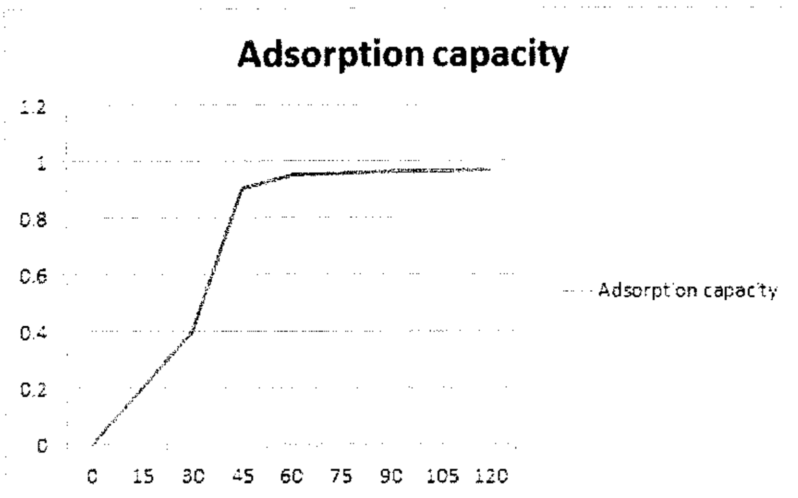

Figure 11: Graph of adsorption capacity

Figure 10 show the percentage of Manganese removal versus contact time. There is sharp increase in the first 60 minutes and then it goes horizontal till the end. We can see that percentage of manganese uptake is nearly 100% after 60 minutes. This result confirms the efficiency of banana peels. We can say that increasing the contact time would increase the percentage metal uptake until the adsorption reaches equilibrium which is nearly 60 minutes. Figure 11 show the adsorption capacity of banana peels. Same as figure 10, the adsorption capacity also increase until it reaches the equilibrium.

- Test for adsorbent dosage:

Table 3: Experiment of adsorbent dosage

Contact time (min)	Residue conc. (ppm), C_t	Initial conc. (ppm), C_o	Weight of adsorbent (g), m	Volume of solution (L), V	% Mn removal
120	1.67	20	0.5	0.1	91.65
120	1.05	20	1	0.1	94.75
120	0.95	20	1.5	0.1	95.25
120	0.76	20	2	0.1	96.2
120	0.7	20	2.5	0.1	96.5

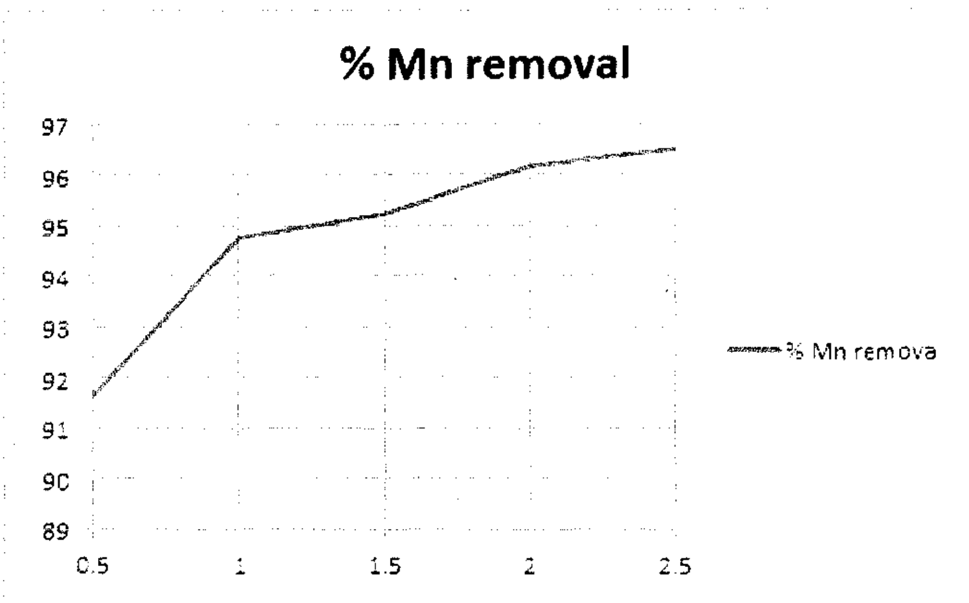

Figure 12: Graph of % Mn removal vs adsorbent dosage

Figure 12 show the graph of percentage Mn removal versus different adsorbent dosage. We can see that the graph is increase but the slope is decreased. We can conclude that the percentage of Mn removal is increased if we increase the adsorbent dosage until it reaches the maximum of Mn concentration that it can adsorp.

- Test for different Mn concentration:

Table 4: Experiment of different Mn concentration

Contact time (min)	Residue conc. (ppm), C_t	Initial conc. (ppm), C_o	Weight of adsorbent (g), m	Volume of solution (L), V	% Mn removal
120	0.125	10	2	0.1	98.75
120	0.7	20	2	0.1	96.5
120	1.59	30	2	0.1	94.7
120	2.56	40	2	0.1	93.6
120	4.64	50	2	0.1	90.72

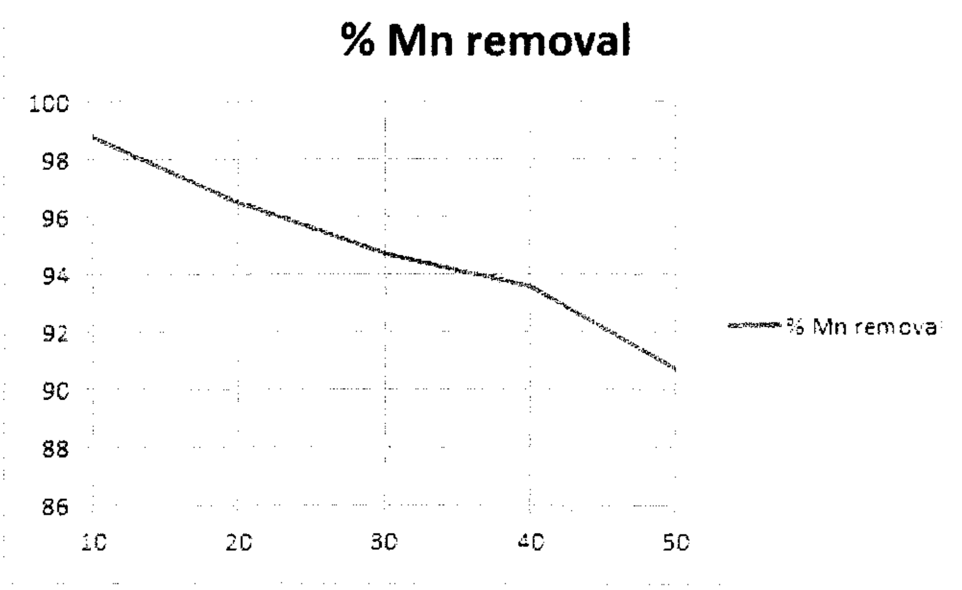

Figure 13: Graph of & Mn removal vs Mn initial concentration

Figure 13 show the graph of percentage Mn removal versus different Mn concentration. We can see that the graph is decreased as the concentration of Mn is increased. We can conclude that the banana peels dosage is limited to adsorb the Manganese as we increased the Mn concentration.

l.2 Isotherm Generation

'reundlich equation,

$$\frac{x}{m} = KC^{1/n}$$

$$\log\left(\frac{x}{m}\right) = \frac{1}{n}\log C + \log K$$

x/m = mass of adsorbate adsorbed per unit mass of adsorbent, mg adsorbate/ gBP

K_f = Freundlich capacity factor, (mg adsorbate/ g BP) (L water/mg adsorbate)$^{1/n}$

C_e = equilibrium concentration of adsorbate in solution after adsorption, mg/L

1/n = Freundlich intensity parameter

Langmuir equation,

$$\frac{x}{m} = \frac{abC}{1 + aC}$$

$$\frac{1}{\frac{x}{m}} = \frac{1}{abC} + 1/b$$

Table 5: Freundlich and Langmuir Isotherm Data

volume of solution (L)	weight of adsorbent (g)	residue conc. (Ce)	intia conc. (ppm)	% Mn removal	adsorption capacity (mg/g)	1/Ce	1/q	log Ce	log q
0.1	2	0.125	10	98.75	0.49375	8	2.02531646	-0.90308999	-0.30649289
0.1	2	0.7	20	96.5	0.965	1.42857143	1.03626943	-0.15490196	-0.01547269
0.1	2	1.59	30	94.7	1.4205	0.62893082	0.70397747	0.201397124	0.152441238

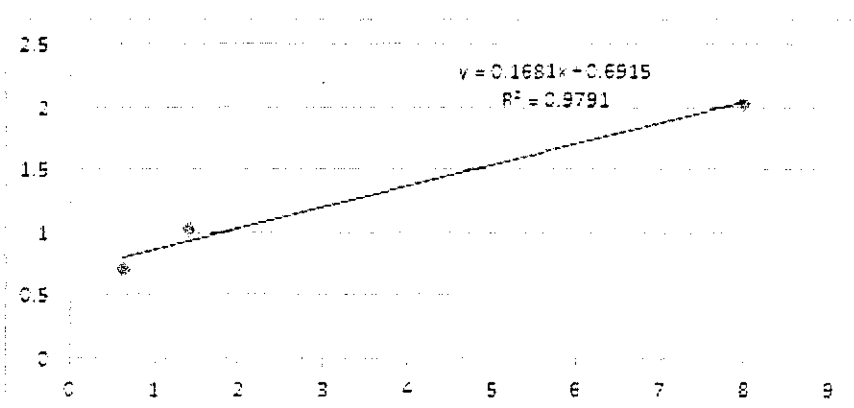

Figure 14: Langmuir Isotherm

Using y= mx + c, we know that

1/ab = m and 1/b = c

y = 01681x + 0.6915

$$\frac{1}{ab} = 0.1681$$

$$\frac{1}{b} = 0.6915$$

$$b = 1.446$$

$$a = 4.1136$$

$$\frac{1}{\frac{x}{m}} = \frac{1}{5.948C} + \frac{1}{1.446}$$

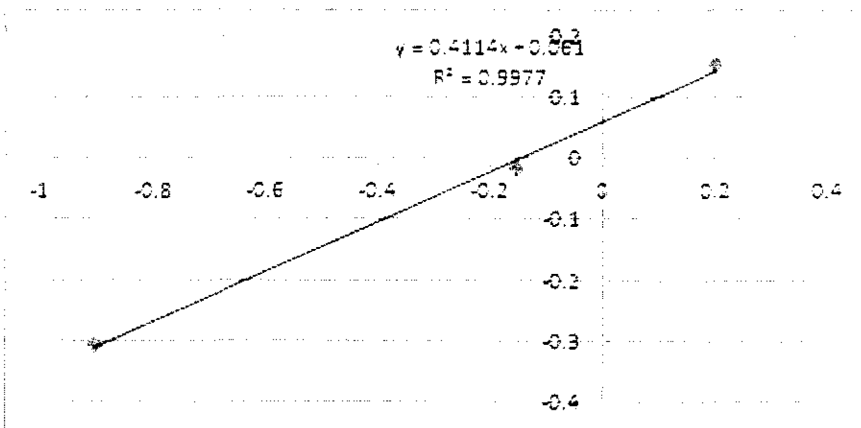

Figure 15: Freundlich Isotherm

CHAPTER 5

CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions:

There are several conclusions that we can made from this research and experiment from the objective that we targeted earlier,

- The banana peels is capable to be the alternative adsorbent in adsorption of manganese as it's has high surface area, microporous structure and high degree of surface reactivity.
- The adsorption is increased as the contact time increased and the optimum time to reach equilibrium is about 60 minutes.
- The adsorption is increase as the adsorbent dosage increased.
- The adsorption is decreased as the Manganese concentration increased.
- The Mn adsorption activities are well described in Freundlich and Langmuir isotherm.

5.2 Recommendations:

1. Further experiment should study the effect of pH to the adsorption activities.
2. Further should use the Brunauer-Emmet-Teller (BET) method. Using BET results, the relation between adsorption capacity and the surface area properties can be justified.
3. To determine the adsorption capacity of other metal ion such as Lead and Nickel.
4. To use different fruit peels such as lemon peel and orange peel as the adsorbent.

REFERENCES

Calace,N., Muro, Di A., Nardi, E., Petronio, M.B., Pictroletti, M., (2002) *Adsorption isotherms for describing heavy metal retention in paper mill sludges*. Ind Eng. Chem. Res., 41, 5491-5497.

Kadirvelu, K., Thamaraiselvi, K., Namasivayam, C., (2001a) *Removal of Heavy metal from industrial waste water by Adsorption onto activated Carbon prepared from agricultural solid waste*. Bioresour Technol., 76, 63-65.

Bhattcharya. A.K., Mandal. S.N., Das, S.K., (2006) *Adsorption of Zn(II) from aqueous solution by using different adsorbents.* Chemical Engineering Journal. 123, 43-51.

Axtell. N.R., Sternberg. S.K.P., Claussen K., (2003) *Lead and Nickel removal using microspore and lemna minor*, Bioresour. Technol., 89, 41-48.

Bailey, S.E., Olin, T.U., Bricka, R.M., Adrian, D.D., (1999) *A review of potentially low-cost adsorbents for heavy metals.* Water Res., 33, 2469-2479.

King, P., Srivinas, P., Prasanna Kumar, Y., Prasad, V.S.R.K (2006) *Sorption of copper (II) ion from aqueous solution by Tectona grandis (Teak leaves powder),* J. Hazard Mater., B 136, 560-566.

Metcalf and Eddy, (2004) *Wastewater Engineering Treatment and Reuse*. New York, Mc Graw Hill.

Srivastasa S.K., Pant N. and Pal N., (1987), Water Res., 21 (11) 1389-94.

Muhammad, N., Parr, J., Smith, M.D., and Wheatley, A.D., (1998) *"Proceedings of the 23rd WEDR International Conference on Water Supply and Sanitation"* Removal of Heavy Metals by Slow Sand Filtration, Islamabad.

Rahman I. A., Ismail J, and Osman H., (2000) *Malaysian Journal of Chemistry*, 2(1), 12-15.

Nomanbhay S.N., and Palanisamy K, (2004) *Removal of Heavy Metal from Industrial Wastewater using Chitosan Coated Oil Palm Shell Charcoal*. n.p.

Huang, C.P., and Blankenship, B.W., (1989), *"Water Research", The Removal of Mercury (II) from Dilute Aqueous Solution by Activated Carbon*, 18: 37-46.

Kenish M.J. (1992). *Ecology of Estuaries: Anthropogenic Effects*. CRC Press, Inc., Boca Raton, FL.

Volesky, B. (1990). *Biosorption of Heavy Metal*. CRC Press, Inc., Boca Raton, Floride, p 10-11.

APPENDIX I

Figure 16: CHNS Analyzer

Figure 17: FT-IR Analyzer

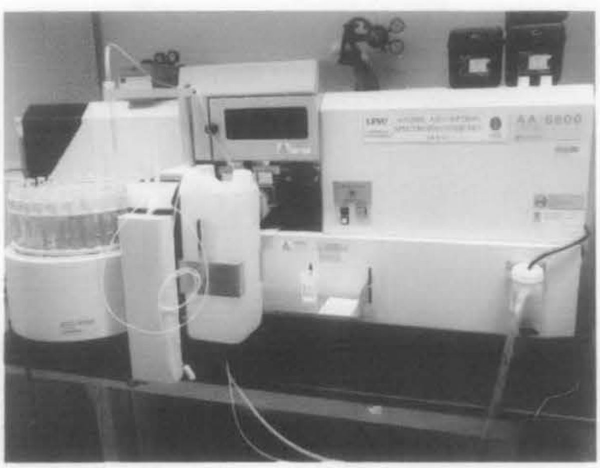

Figure 18: Atomic Adsorption Spectrophometer (AAS) Analyzer

APPENDIX II

Calculation for Percent Metal Uptake

The calculation for metal uptake is such as below:

$$\frac{\text{Initial concentration} - \text{Final concentration}}{\text{Initial Concentration}} \times 100\%$$

Calculation for Adsorption Capacity

The calculation for adsorption capacity is such as below:

$$\frac{\text{Initial concentration} - \text{Final concentration}}{\text{Weight of rice husks in gram (g)}} \times \text{Volume of solution in liter (L)}$$