ADSORPTION OF PHENOL FROM AQUEOUS SOLUTIONS USING INCINERATED SEWAGE SLUDGE

By

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ABSTRACT

A study had been carried out to determine the potential use of sewage sludge ash (SSA) as an adsorbent in removing phenol from aqueous solution. Parameters which contributed to affect phenol removal were initial phenol concentration, contact time, adsorbent dosage, pH and particle size of adsorbent. Results showed that the adsorption capacities of adsorbent (K_f) for phenol decreased from 14.89 mg/g to 0.68 mg/g as initial phenol concentration increased from 0.1 mg/l to 5.0 mg/l. Results revealed that solution with higher initial phenol concentration required longer time to reach equilibrium state. Adsorption capacity of adsorbent (K_f) decreased from 14.89 mg/g to 0.66 mg/g as contact time increased from 240 minutes to 1200 minutes. Furthermore, pH was found to affect the adsorption capacity where as pH decreased from original (9 - 12) to neutral (7 - 8), adsorption capacity of adsorbent increased from 0.68 mg/g to 3.0 mg/g. Moreover, it was shown that as particle size of adsorbent decreased from 150 - 212 μm to 63 - 149 μm, adsorption capacity of adsorbent (K_f) was decreased from 2.06 mg/g to 0.68 mg/g. Adsorption isotherm analysis showed that the experimental data fit Freundlich model in most conditions.

ABSTRAK

Kajian telah dilakukan untuk mengetahui potensi abu enapcemar kumbahan dalam penyingkiran *"phenol"* daripada larutan berair. Parameter-parameter yang mempengaruhi penyingkiran *'phenol"* terdiri daripada kepekatan awal *"phenol"*, masa tindakbalas, dos penyerap, nilai pH dan saiz butiran penyerap. Keputusan menunjukkan bahawa kapasiti penyerapan abu enapcemar (K_f) bagi *"phenol"* menurun daripada 14.89 mg/g kepada 0.68 mg/g apabila kepekatan awal *"phenol"* meningkat daripada 0.1 mg/l kepada 5.0 mg/l. Keputusan mendedahkan bahawa larutan dengan kepekatan awal *"phenol"* yang lebih tinggi memerlukan lebih lama masa untuk mencapai keadaan keseimbangan. Kapasiti penyerapan bagi abu enapcemar (K_f) menurun daripada 14.89 mg/g kepada 0.66 mg/g apabila masa tindakbalas meningkat daripada 240 minit kepada 1200 minit. Selain itu, nilai pH didapati mempengaruhi kapasiti penyerapan iaitu apabila nilai pH menurun daripada keadaan semulajadi (9 - 12) kepada neutral (7 - 8), kapasiti penyerapan abu enapcemar meningkat daripada 0.68 mg/g kepada 3.0 mg/g. Selain daripada itu juga, telah ditunjukkan bahawa apabila taburan saiz butiran abu enapcemar menurun daripada 150 - 212 μm kepada 63 - 149 μm, kapasiti penyerapan abu enapcemar (K_f) menurun daripada 2.06 mg/g kepada 0.68 mg/g. Analisis penyerapan isoterma menunjukkan bahawa data ujikaji sesuai dengan model Freundlich dalam kebanyakan keadaan.

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I sincerely hope that this study will be a contribution toward the goal of better engineering in the field of water quality. I constantly remind myself of the following quote from Baba Diodum; "In the end we will conserve only what we love, we will love only what we understand and we will understand only what we are taught".

Should there be any omissions, I would like to offer my apologies in advance. There is little, apart from mistakes, for which I can claim credit. My contribution, if any, is in correlation and interpretation of the available information. Even on this there are bound to be differing views, because the entire scientific truth on the subject has not yet been revealed, and interpretations at variance do not imply criticism or disrespect.

Finally, I would like to thank all people, whose have been helping me in this study and especially to my parent for giving me support in my life.

I certify that an Examination Committee met me on **3 November 2004** to conduct the final examination of **Wan Afnizan Bin Wan Mohamed** on his **Masters of Science** thesis entitled "**Adsorption of Phenol from Aqueous Solution Using Incinerated Sewage Sludge**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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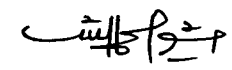
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



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C_o	Initial phenol concentration (mg/l).
C_e	Phenol concentration in solution at equilibrium (mg/l).
K_d	The equilibrium constant.
K_f	Adsorption capacity (mg/g).
1/n	Adsorption intensity.
M_1	Phenol concentration of stock solution (mg/l).
M_2	Phenol concentration to be prepared (mg/l).
q_e	The amount of phenol adsorbed at equilibrium (mg/g).
q_m	The maximum adsorption capacity of adsorbent (mg/g).
V_1	Volume of solution needed to be taken from stock solution (ml).
V_2	Volume of distilled water to be added into diluted volumetric flask until it reached the mark (ml).
ϕ	Diameter.

CHAPTER 1

INTRODUCTION

More than two thousand chemical contaminants have been found in wastewater and about 750 of which have been identified in drinking water. Of these, more than 600 are of organic origin (Singh and Rawat, 1994). Phenols are among the most common water pollutions and it is classified as an organic pollutant. They are used as algicides, bactericides, fungicides, herbicides, insecticides and molluscicides in a variety of industrial, agricultural and domestic fields. Phenols are introduced into surface water from industrial effluents such as those from oil refringeries and the coal tar, plastics, leather, paint, dyeing, pharmaceuticals and steels industries as well as from agricultural run off, domestic waste water and chemical spills (Singh and Rawat, 1994).

Phenol has been included in the USEPA list of priority pollutants (Idris and Saed, 2003). Therefore the treatment of them is a necessity. Several physical, chemical and biological processes are used for the removal of phenol from aqueous solutions.

Chemical oxidation, liquid membrane, osmosis, chemical precipitation, filtration, electrodialysis and adsorption are among those methods most commonly employed (Idris and Saed, 2003).

Adsorption is currently being used for the removal of organic and inorganic compounds from aqueous phases and since 1940s, activated carbon has become the water industry's standard for this purpose. Activated carbon is the most widely and effectively used adsorbent. A typical activated carbon particle, whether in a powdered or granular form, has a porous structure consisting of a network of interconnected macropores, mesopores and micropores that provide a good capacity for the adsorption of organic molecules due to its high surface area. However this conventional activated carbon suffers from a number of disadvantages. It is quite expensive and the higher quality is desired the greater the cost would be. Therefore various attempts have been made by researchers to utilize another material to be converted as activated carbon.

In recent years, numerous low cost adsorbent materials have been evaluated for their capacity to remove phenol from aqueous solution. Among adsorbents that have been tested are bentonite (Banat *et. al.*, 2000), rice husk (Munaf *et. al.*, 1997), slash pine bark (Edgehill and Lu, 1998), fly ash generated in the sugar industry (Gupta *et. al.*, 1998), fly ash from the thermal power station (Kumar *et. al.*, 1987; Singh and Rawat, 1994) and local soil (Abuzaid *et. al.*, 2000).

Sewage sludge is being generated in an ever increasing amount due to the rapid urbanization and higher effluent criteria implemented in recent decades. Without proper treatment and disposal, it will cause a secondary pollution problem in the environment. Normally, the conventional disposal options for sewage sludge include landfill, application to farmland and forestry, incineration and sea dumping. Unfortunately, due to competition for landfill space, higher costs and more stringent environmental standards applied, the disposal of sewage sludge is not sustainable anymore. Generally, sewage sludge is carbonaceous in nature and rich in organic matter. Therefore, it has the potential to be used as activated carbon. This replacement could offer the combined benefits of reducing the volume of sludge and producing a valuable adsorbent with lower cost than commercial activated carbons.

In this study the adsorption capacity of sludge generated from sewage treatment plant was examined. The sewage sludge was tested for its adsorption capacity to remove phenol from aqueous solution. The objectives of this study include:-

i. To evaluate the performance and effectiveness of incinerated sewage sludge in removing phenol by adsorption process.

ii. To determine the effect of initial phenol concentration, contact time, pH of solution, dosage, and particle size of adsorbent on the adsorption performance.

iii. To evaluate the applicability of the Langmuir and Freundlich isotherm.

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