Copper Removal from Hazardous Waste Landfill Leachate using Peat as an Adsorbent

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ABSTRACT: This study investigated the removal of copper from hazardous waste landfill leachate. Peat was used as absorbent due to its high absorption capacity for the heavy metal. To study the efficiencies of peat as an absorbent, fresh peat and dried peat which have different characteristics were used. For each peat type, three parameters that can have effect on absorbent performance were investigated, including absorbent dose, contact time and the used of hydrochloric acid. Batch kinetic study was conducted using Jar Tester to determine the optimum conditions of peat absorption for removal of copper from leachate. The highest removal of copper was obtained using 400 g of dried peat that removed 95% of copper content from its initial concentration. The addition of hydrochloric acid to fresh peat and dried peat shows that the latter has higher ability to absorb copper compare to the former. The rate of copper (II) adsorption increases with the quantity of acid added. The highest percentage of removal rate by the dried peat observed was 95.96 % and 98.7 % for the fresh peat.

Keywords: copper, absorbent, peat

Introduction

Removal of heavy metals from wastewater is usually achieved by physical and chemical processes which include precipitation, coagulation, reduction membrane process, ion exchange and adsorption (Mukherjee et. al, 2007). Adsorption has advantages over the other methods because of simple design with a sludge free environment and involves low investment in term of both initial cost and land required.

Copper can be found in many wastewater sources including printed circuit board manufacturing, electronics plating, painting manufacturing and printing operations. This compound can be removed from wastewater by precipitation as an insoluble salt, precipitation as metallic copper and by ion exchange.

Various methods exist for the removal of heavy metal from wastewater which includes chemical precipitation, coagulation, membrane technology, electrolytic reduction, ion exchange and adsorption.

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Currently, the most widely used method of removing heavy metals from solutions is by increasing the pH of the effluent and then converting the soluble metal into an insoluble form. Ion exchange is also a method of choice for the heavy metal removal.

As a part of the effort to develop and improvise new adsorbent as an alternative to the activated carbon, peat has been used in this study. It was based on a previous study that it can be an effective adsorbent for a wide range of biosphere pollutants. Peat is known to have excellent ion exchange properties similar to natural zeolites. Due to the polar character of peat, its specific adsorption potential for dissolved solids, such as metal and polar organic molecules is high (Brown et. al., 2000). It can be used alone or as a constituent of combined adsorbents and complex composite materials (Novoselova and Sirotkina, 2008). The drainage of mining leachate through a white cedar bog has resulted in a complete adsorption of some trace metals and a significant reduction in the level of other metals. In addition to studying the natural constituents of peat bogs, considerable attention has been focused on the potential of peat as a commercial adsorbent for the removal of toxic metals in contaminated wastewaters. As far back as 1993, the potential of peat as an ion exchange medium for metals such as copper, zinc, lead and mercury was realized. The aim of this study is therefore to investigate the removal of copper from hazardous landfill leachate using peat. The landfill in our study is a final disposal for hazardous waste that has gone through certain treatment in Waste

Management Centre, Port Dickson, Negeri Sembilan. The leachate contains high concentration of pollutant such as heavy metal including copper.

Materials and Method

Leachate

Leachate sample was collected at leachate collection sump secured landfill, Waste Management Centre, Port Dickson Negeri Sembilan. The metal concentration in leachate was analyzed using AAS.

Peat

The peat was obtained from a nursery in Alor Gajah. The peat was sieved to get peat particles of similar size. Smaller particle size increases surface area of the peat for absorption. Fresh peat and dried peat were used. The peat was placed in a tray and dried in the oven at temperature 90^0C. Both fresh peat and dried peat were used in this study to investigate if drying affects the adsorption capacity of peat. The effect of acid addition to the peat was also evaluated by treating the peat with difference volume of hydrochloric acid to investigate if acidification would help to increase the copper absorption.

Jar tester

This study was conducted in a series of batch absorption experiment using Jar Tester to evaluate the effects of operating parameters on adsorption of copper from leachate by peat. A speed of 150 rpm was used to stir the sample.

Experimental

Two sets of experiment were conducted and the jar tester was running for 1 h using different types of adsorbents.

The first experiment used 100 - 500 g of either dried or fresh peat mixed with 2 liter of leachate with the aim to determine the amount for both types of peat on the adsorption of copper. For the second experiment, five sets of experiment were carried out using different volume of hydrochloric acid (0.3 M), added to 100 g peat. In the third experiment, the effect of contact time to copper adsorption was investigated. 100 g of dried or fresh peat were used. After stirring for 1 h in the Jar Tester, the peat was left in the leachate for one to three days.

Results

Dried vs fresh peat

The results show that when 100 g of dried peat was used, 0.456 ppm or 16% of copper were reduced from the initial concentration while 100 g of fresh peat adsorbed 0.375 ppm or 13.16% of copper from the initial concentration.

When the amount of peat was increased from 100 g to 500 g, the amount of copper absorbed also increased and reached the maximum lead removal rate when 400 g or 500 g were used, **FIG. 1**.

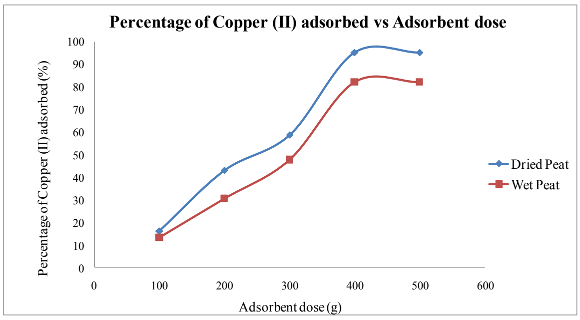

FIG. 1- The effect of peat quantity on absorption of Copper

The percentage of copper adsorbed increases with the increment in adsorbent dose owing to the availability of more surface functional groups and surface area at higher adsorbent doses (Nasim et. al., 2003). Our results show that fresh peat exhibits a similar trend of absorption with a slightly lower removal efficiency even when a larger amount of peat was used.

Effect on the addition of hydrochloric acid

Organic acid solutions such as hydrochloric acid, nitric acid, sulfuric acid, tartaric acid, citric acid, and thioglycollic acid that can act as modifying agents may affect the efficiency of metal adsorption in wastewater treatment (Wan Ngah and Hanafiah, 2007). **TABLE 1** and **TABLE 2** show that the amount of copper removed increases with the volume of hydrochloric acid used and reaches the maximum absorption rate when 125 mL of hydrochloric acid was added. This shows that acidity affects the efficiency of copper adsorption (Marina and Mile, 2006).

Effects of contact time

TABLE 3 shows that there were no significant changes on the percentage of copper adsorbed over a duration of 1-3 days most likely because the initial equilibrium was attained on the first day.

TABLE 1- Removal of Copper (II) by using dried peat mixed with hydrochloric acid

Sample	Adsorbent	Initial Concentration (ppm)	Final Concentration (ppm)	Volume Adsorbed	Percentage Adsorbed (%)
1	100g Dp + 50 ml HCL + Leachate	2.85	2.365	0.485	17.02
2	100g Dp + 75 ml HCL + Leachate	2.85	1.482	1.368	48.00
3	100g Dp + 100 ml HCL + Leachate	2.85	1.063	1.787	62.70
4	100g Dp + 125 ml HCL + Leachate	2.85	0.115	2.735	95.96

Note: Dp = Dried peat

TABLE 2- Removal of Copper (II) by using fresh peat mixed with hydrochloric acid

Sample	Adsorbent	Initial Concentration (ppm)	Final Concentration (ppm)	Volume Adsorbed	Percentage Adsorbed (%)
1	100g Wp + 50 ml HCL + Leachate	2.85	1.116	1.734	60.84
2	100g Wp + 75 ml HCL + Leachate	2.85	0.707	2.143	75.19
3	100g Wp + 100 ml HCL + Leachate	2.85	0.059	2.791	97.93
4	100g Wp + 125 ml HCL + Leachate	2.85	0.037	2.813	98.70
5	100g Wp + 150 ml HCL + Leachate	2.85	0.037	2.813	98.70

Note: Wp=Wet peat

TABLE 3- Effect of contact time by using dried peat and fresh peat for copper removal

Time (day)	Adsorbent	Initial Concentration (ppm)	Final Concentration (ppm)	Volume Adsorbed	Percentage Adsorbed (%)
1	100g Dp + Leachate	2.85	2.394	0.456	16.00
	100g Wp + Leachate	2.85	2.475	0.375	13.16
2	100g Dp + Leachate	2.85	2.395	0.455	15.96
	100g Wp + Leachate	2.85	2.474	0.370	13.19
3	100g Dp + Leachate	2.85	2.398	0.452	15.85
	100g Wp + Leachate	2.85	2.477	0.373	13.08

Conclusion

Peat has gained attention to be an effective and low cost adsorbent to treat heavy metal from leachate. The adsorption of the peat depends on the characteristics of the peat. Dried peat is likely to have more available adsorption surface sites compared to fresh peat. Some of the surface sites of the latter might bind with H^+ ion from water causing it to have lower ability to adsorb copper. Our results also show that pH significantly affects copper adsorption. We conclude that peat can be a good copper removal medium when it is treated with a suitable amount of hydrochloride acid.

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