Sustainable Removal of Heavy Metal using Extracted *Pandanus amaryllifolius* Roxb.

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Keywords: Pandan leaves; biosorption; heavy metal; copper

Abstract. Discharge of heavy metals from metal processing industries is known to have adverse effects to the environment. Conventional treatment technologies for removal of heavy metals from aqueous solution are not economical and generate huge quantity of toxic chemical sludge. Biosorption of heavy metals by metabolically inactive non-living biomass of microbial or plant origin is an innovative and alternative technology for removal of these pollutants from aqueous solution. Therefore, in this study, it is aimed to investigate the potential of pandan leaves as a biosorbent to remove heavy metal, copper. The pandan leaves were extracted via solvent extraction method. The effect of dosage of biosorbent, pH aqueous solution, and the biosorption contact time towards removal of copper (Cu^{2+}) ions were studied. The concentration of copper ions was analyzed by using atomic adsorption spectroscopy (AAS). The maximum biosorption of Cu^{2+} ions was obtained up to 70 % for 5ppm of initial copper ions loading by 1 hour.

Introduction

The term "heavy metals" refers to natural metallic elements with a density greater than 5g/cm^3. Some heavy metals are an important part of our diet as trace elements; while others are toxic in even at low concentrations. In common environment, the presence of heavy metals can be found in variety of living creature including man and these metals have been widely use in the industries. Although heavy metals have bring many benefit to humankind and industries, the toxic heavy metals waste from industries or partially lost through human technological activities have become a major concern nowadays which can give serious health problem to human. These metals would accumulate in living tissues throughout the food chain and threaten to living thing. Thus, it is necessary to treat heavy metals before it is been discharged into environment.

The heavy metal used in this experiment was copper. Copper is an essential nutrient, required by the body in very small amounts. However, Environmental Protection Agency (EPA) has found that copper to potentially cause the following health effects when people are exposed to it at levels above the action level. Short periods of exposure can cause gastrointestinal disturbance, including nausea and vomiting. Use of water that exceeds the action level over many years could cause liver or kidney damage. People with Wilsons disease may be more sensitive than others to the effect of copper contamination and should consult their health care provide.

Conventional methods for removing metals from aqueous solutions include chemical precipitation, chemical oxidation or reduction, ion exchange, filtration, electrochemical treatment, reverse osmosis, membrane technologies and evaporation recovery. These processes may be ineffective or extremely expensive especially when the metals in solution are in the range of 1-100 mg/l [1]. Another major disadvantage with conventional treatment technologies is the production of toxic chemical sludge and its disposal/ treatment becomes a costly affair and is not eco-friendly.

Therefore, removal of toxic heavy metals to an environmentally safe level in a cost effective and environment friendly manner assumes great importance. In light of the above, biological materials have emerged as an economic and eco-friendly option. Biomaterials of microbial and plant origin interact effectively with heavy metals. Biosorption is potentially an attractive technology for treatment of wastewater for retaining heavy metals from dilute solutions. Biosorbent for the removal of metals/dyes mainly come under the following categories: bacteria, fungi, algae, industrial wastes, agricultural wastes and other polysaccharide materials [2]. Some biosorbents can bind and collect a wide range of heavy metals with no specific priority, whereas others are specific for certain types of metals. When choosing the biomass for metal biosorption experiments, its origin is a major factor to be taken into account. Biomass can come from (i) industrial wastes which should be obtained free of charge; (ii) organisms easily available in large amounts in nature; and (iii) organisms of quick growth, especially cultivated or propagated for biosorption purposes [3]. Cost effectiveness is the main attraction of metal biosorption, and it should be kept that way.

This study was focused on biosorption of copper ion using extracted *Pandanus amaryllifolius* Roxb. leaves (pandan leaves). The use of pandan leaves as heavy metals removal has never been reported before. The pandan leaves were extracted via solvent extraction. Solvent extraction is the common method of extraction which uses organic solvent to extract the essential oils. The common organic solvents used are petroleum ether, methanol, ethanol or hexane [4].

Materials and Methods. Fresh pandan leaves were bought from a local market. Pure ethanol (99.9%), 0.1M sodium hydroxide (NaOH) solutions, 0.1M hydrochloric acid (HCl) solution, and copper chloride powder were purchased from Fluka.

Extraction of Pandan Leaves. Prior to extraction, approximately 200g of pandan leaves were cleaned, cut into small pieces, and immediately oven dried in forced convection conventional oven at 30ºC for 48 hours. Then, the pandan leaves were grounded into 150 micron. Ethanol was used as solvent to carry out the solvent extraction. 5g of pandan leaves were soaked with 100ml pure ethanol (99.9%) for 24 hours as a stock solution.

Heavy Metal Solution Preparation. 100ml of 100ppm Cu^{2+} ions solution (stock solution) was prepared by diluting the copper chloride powder. After that, the stock solution was used to obtain 5ppm of Cu^{2+} ions solution. Besides, an analytical grade of HCl and NaOH solutions was used for pH adjustment.

Adsorption Study. A series of biosorption experiments was carried out; 0.2g of pandan leaves in 4ml of ethanol was added to a 15ml aqueous solution that contained 5ppm of copper (Cu^{2+}) ions. The pH of the aqueous solution was set at 5.5 by using HCl and NaOH solutions. Then the mixture was stirred for 1 hour and then was analyzed. Solution of pH 3, 4, 5, 6, and 7 were used to study the effect of pH on the biosorbent. In this experiment, 0.2g of pandan leaves in 4ml of ethanol was added to a 15ml aqueous solution that contained 5ppm of Cu^{2+} ions. After that, the solutions were stirred for 1 hour at constant speed. Different contact time was set for 5, 30, 60, 150, and 240 minutes at constant speed to study the relationship between contact time and biosorbent process. 0.2g of pandan leaves in 4ml of ethanol was added to a 15ml aqueous solution that contained 5ppm of Cu^{2+} ions. Different mass of biosorbent were used in 4ml of ethanol that are 0.1, 0.2, 0.3, 0.4, and 0.5g and stirred for 1 hour at constant speed. Finally, the analysis was determined using Atomic Absorption Spectroscopy (AAS).

Results and Discussions.

Effect of Contact Time on Biosorption of Copper (Cu^{2+}) Ions. Equilibrium time is an important operational parameter for a biosorption process. Fig. 1 shows percentage of removal of Cu^{2+} ions by difference mass of contact time used. The biosorption rate was fast within the first 60 minutes of contact time with the primary rapid uptake, and then slowly reached equilibrium. The biosorbent became saturated within 240 minutes. The results clearly indicated that rate of adsorption is higher at the beginning and this is due to availability of a large number of active sites on the biosorbent. As the sites were exhausted, the rate of adsorption is gradually slow down and remains constant. From the result, a time of 60 minutes is sufficient to obtain maximum copper removal percentage. Therefore, 60 minutes was considered to be the equilibrium time for further studied of biosorption. The maximum removal percentage achieved was about 57%.

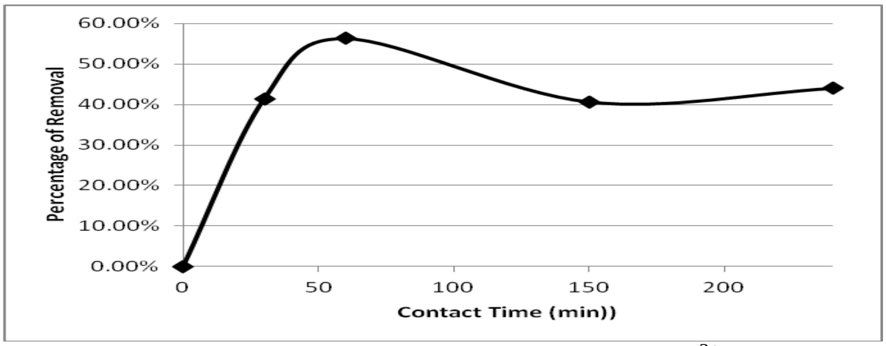

Fig. 1 Effect of contact time on biosorption of Cu^{2+} ions

Effect of Biosorbent Concentration on Biosorption of Copper (Cu^{2+}) Ions. The number of available sites and exchanging ions for the biosorption depends upon the amount of biosorbent used. Fig. 2 shows percentage of removal of Cu^{2+} ions by difference mass of biosorbent used. The mass of biosorbents was varied between 0.1 to 0.5g and other parameters were kept at constant.

The result denotes that at very low biosorbent dosage, the biosorbent surface became saturated with the Cu^{2+} ions and the amount of copper ions residual still large. However, higher Cu^{2+} ions removal corresponding to the increasing of biosorbent concentration. This result is fitted with the theory because more binding sites for ions are available at higher dose of biosorbents. After some point, biosorption capacity was steady with biosorbent concentration due to the screen effect between cells; this produced a block of the cell active sites by an increase of biosorbent in the system. The removal efficiency of Cu^{2+} ions was increased from about 48 to 70 % when the dosage of adsorbent increased from 0.1 to 0.5g.

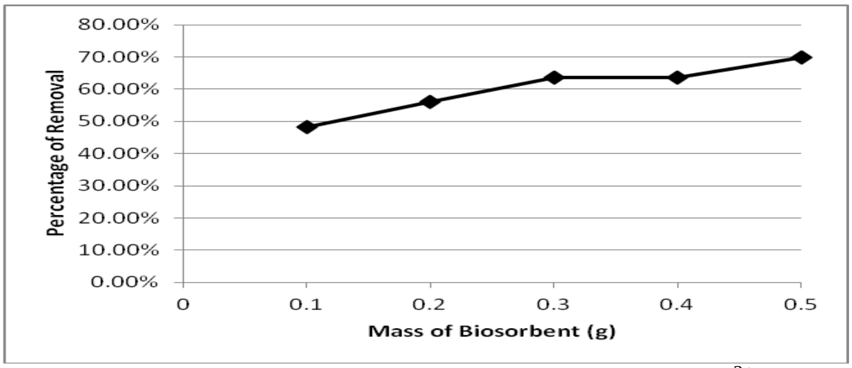

Fig. 2 Effect of absorbent dosage on biosorption of Cu^{2+} ions

Effect of pH on Biosorption of Copper (Cu^{2+}) Ions. Biosorption of metal ions by extracted pandan leaves was studied at pH 3 to 8. Fig. 3 shows percentage of removal versus pH in solution. As can be seen, the uptake of Cu^{2+} ions depends on pH, where the copper removal efficiency increased with increasing of pH. Ineffective of Cu^{2+} ions removal at low pH indicated that the biosorption process depend on ionic attraction. In fact, Cu^{2+} ions are positively charged metal cations. Therefore, when pH decreases the cell surface becomes more positively charged, eventually reducing the attraction between the biosorbent and the Cu^{2+} ions. Metal uptake increased with pH 3 to 10, this is due to more ligands with negative charge being exposed with the subsequent increase in attraction sites to positively charged metal ions.

Many other researchers also observed there are optimum biosorption as the pH increase, as the Cu^{2+} ions would precipitated due to high concentration of OH^- ions in the adsorption medium and biosorption studies could not be performed. However, there is no optimum pH for copper in this study although the pH is up to 10. The percentage removal of Cu^{2+} ions was from 33% to 51%.

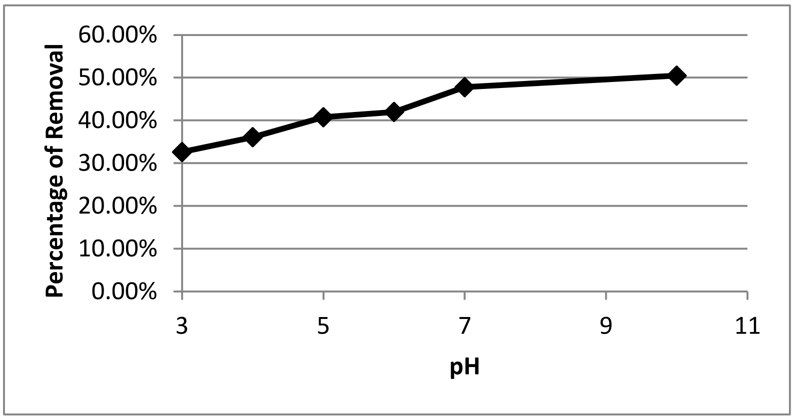

Fig. 3 Effect of pH on Biosorption of Cu^{2+} ions

Conclusions

In conclusion, extracted pandan leaves are highly potential as a biosorbent agent for the removal of Cu^{2+} ions. The maximum biosorption of Cu^{2+} ions was obtained up to 70% for 5ppm of initial Cu^{2+} ions loading by 1 hour.

Acknowledgement

The authors would like to extend their sincere gratitude to the Ministry of Higher Education Malaysia (MOHE) for the financial supports received under Exploratory Research Grant Scheme (Vote no. R.J130000.7844.4L052).

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