Isothermal Equilibrium and Kinetics Study on the Adsorption of Copper (II) Ions by Dried Water Hyacinth (*Eichhornia crassipes Linn.*) Biomass

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ABSTRACT

This study dealt with the determination of copper (Cu^{2+}) ion adsorption capacity of dried roots and above ground vegetative structure of *Eichhornia crassipes* taken from Lake Palacpacquen in San Pablo, Laguna. Both the adsorption by roots and aerial portion fitted the Langmuir and Freundlich models suggesting that the biosorption mechanism is complex. The dried roots and aerial part biomass of *E. crassipes* were excellent biosorbents for copper with q_{max} value of 2000.00 mg/g and 714.29 mg/g respectively. Results also showed that adsorption of copper by dried roots is significantly higher than that of dried aerial part (p value= 0.0236). Results of the study also showed that pH, contact time, biosorbent dose, and initial concentration affect the adsorption capacity. The highest percent sorption by both aerial and root part of the *E. crassipes* biomass was at pH 5.0 giving sorption values of 61.00% and 72.41% respectively. Results of this study revealed that the dried biomass of *E. crassipes* has the potential to clean up wastewater and mine tailings with copper. Further studies on the mechanism of adsorption and adsorption capacity for other heavy metals are recommended.

INTRODUCTION

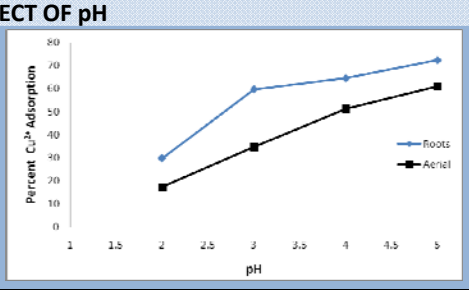
Eichornia crassipes, the biosorbent material that was used in the study, was identified to be an invasive species due to its high proliferation rate and posed problems in Lake Palacpacquen Several studies have proven that live water hyacinth can be used for phytoremediation and recovery of heavy metals but only few studies have ventured on the use of dried water hyacinth biomass for biosorption of heavy metal. This study was an attempt to determine the copper (II) ion adsorption capacity of dried roots and above ground vegetative structure of E. crassipes biomass. It aimed to study the maximum adsorption rate using equilibrium models (Freundlich and Langmuir) and using varying factors (pH, contact time, biosorbent dose, initial concentration). Copper contamination due to mining and heavy metal industries is a problem in the Philippines and this study aims to look at the potential of dried biomass of E. crassipes, to be an alternative solution to waste water treatment.

METHODOLOGY

- PROCUREMENT AND PREPARATION OF MATERIALS
- BIOSORBENT PREPARATION (SAMPLING, WASHING, DRYING, SIEVING)
- BIOSORPTION EXPERIMENTS
  - SORPTION OF METAL AT DIFFERENT INITIAL CONC (25, 50, 100, 250 mg/L)
  - SORPTION OF METAL AT DIFFERENT pH (pH 2,3,4,5)
  - DETERMINATION OF EQUILIBRIUM TIME (0,30,60,90,120,150 minutes)
  - SORPTION OF METAL BY DIFFERENT BIOSORBENT DOSE (0.05, 0.10, 0.20, 0.40, 0.60 grams)
- HEAVY METAL ANALYSIS (Flame AAS)
- DATA ANALYSIS [kinetics and equilibrium (Freundlich and Langmuir)]

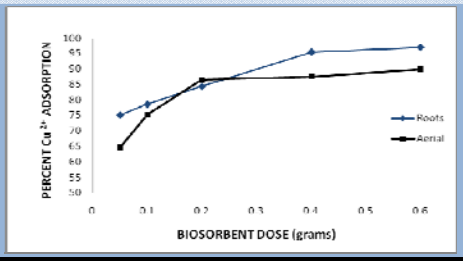
RESULTS

EFFECT OF pH



Percentadsorption of copper increased as the pH increases. The root part of the biomass has higher Cu (II) adsorption compared to the aerial part from pH 2-5.

EFFECT OF BIOSORBENT DOSE



Percent adsorption of copper increased as the biosorbent dose increased.

LANGMUIR AND FREUNDLICH MODELS

Type of Biomass	Langmuir			Freundlich		
	q_{max} (mg/g)	b (L/mg)	R^2	K_f $mg^{(1-1/n)}/g^{1/n}$	N (L/mg)	R^2
ROOTS	2000	0.022	0.922	0.013	1.51	0.91
AERIAL	714	0.109	0.857	0.010	2.02	0.91

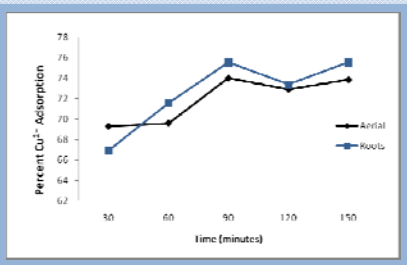
Experimental Parameters for Langmuir and Freundlich Isotherms.

KINETICS

Type of Biomass	R^2 value	
	1st Order Kinetics	2nd order kinetics
ROOTS	0.7998	0.9993
AERIAL	0.8198	0.9989

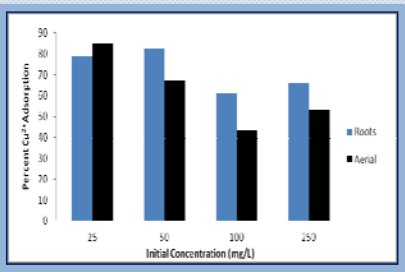
Both adsorption by roots and aerial part of E. crassipes fitted the second order kinetics model.

EFFECT CONTACT TIME



Contact Time affects the adsorption of Cu (II) ions. There is a significant uptake of ions in the first 30 minutes of sorption.

EFFECT OF INITIAL CONC.



Initial concentration affects percent adsorption of heavy metal. Adsorption of heavy metals in roots is higher than that of the aerial part at concentrations from 50 mg/L to 250 mg/L.

CONCLUSION/ RECOMMENDATIONS

It has been proven in this study that both the dried roots and aerial portions of *Eichhornia crassipes* collected from Lake Palacpacquen in San Pablo, Laguna have high copper adsorption capacity. The maximum adsorption capacity exceeded many previously reported uptakes by other biomass and it was found out that the root adsorbed significantly higher amounts of copper. Results of the experiment fitted the Langmuir and Freundlich isothermal equilibrium models thus suggesting a complex adsorption mechanism. Results of the experiment also showed that several factors such as pH, contact time, biosorbent dose, and initial concentration affects the adsorption of copper ions from aqueous solutions. Equilibrium time adsorption was attained 60-90 minutes after shaking the solutions with the biosorbent at 200 rpm in an incubator shaker. It was noted that rapid adsorption occurred within the first 60-90 and eventually rate of sorption decreased after this contact time. Maximum percent adsorption occurred at pH 5, initial concentration 25.00 mg/L. and at 0.60 grams biosorbent.

Since this study revealed that *E. crassipes* can be a potential biosorbent for copper ions in aqueous solution, it is recommended that further studies on this topic will be conducted. Experiments that deal with other heavy metals (such as chromium, mercury, and nickel) and other water pollutants (organic waste) is recommended. Other factors such as temperature may be studied in order to determine the Arrhenius factor.

Since the study found out that dried roots of *E. crassipes* has higher sorption capacity than the top portion biomass, further research may focused on the use of the root parts. Experiments on biosorption using dried roots of *E. crassipes* on the treatment of actual wastewater from heavy metal industries or acid mine tailings may be conducted after further studies on the interaction of copper with other heavy metal were done.