CHAPTER V
CONCLUSION AND RECOMMENDATION

Conclusion

Water hyacinth *(Eichhornia crassipes)*, which was treated with acidic formaldehyde at optimum condition; 5 % FTWH, was selected to remove heavy metal ions from industrial wastewaters. Base on the experimental results obtained, it can be concluded as follow.

Concentration of some heavy metal ions in original water hyacinth

Zinc ions concentration in untreated water hyacinth were greater than those of copper and nickel ions for both of leaching solution and solid sample.

Batch experiments

1. Effect of contact time showed desorption mechanism for Cu^{2+}, Ni^{2+} and Zn^{2+} ions after 20 min. Therefore, 20 min time interval was selected for the effect of formaldehyde experiment.
2. Optimum concentration for treating water hyacinth by acidic formaldehyde solution was 5% formaldehyde, considering both of cost-benefit and pollutant discharge.
3. Sorption isotherm of copper on 5 % FTWH was not fitted to a modified Langmuir isotherm while sorption isotherm of Ni^{2+} and Zn^{2+} may showed curve fitting.

Physical properties and characterization

1. Degree of swelling and moisture content were decreased simultaneously on 5 % FTWH compared with untreated water hyacinth.
2. Base peak of IR spectrum of various water hyacinth substrates showed phenolic broad peak and ether-linked band peak that indicated polyphenolic compounds and crosslinked reaction, respectively.
3. SEM photographs between untreated water hyacinth and 5 % FTWH could not interpreted for supporting the crosslinked reaction.

Column Experiment.

1. Total capacities of Cu^{2+} and Zn^{2+} ions showed well above 1.0 meq/g and low cost which are competitive with those of many synthetic ion exchange resins.
2. Removing mechanisms of FTWH may be possibly the ion exchange, adsorption and chelate forming. However, the main mechanism is probably the ion exchange more than the other mechanism.
3. Dynamic capacities were increased as the concentration of synthetic solution was decreased. Because the Pearson 's correlation coefficient indicated the perfect negative relationship (r = -0.78 to - 1.03).
4. Regeneration of 5 % FTWH packed column was completed by using only 1 bed volume of 0.5 N HCl as an eluent.
5. 5 % FTWH is an excellent substrate for removing and recovering of some heavy metal ions from industrial wastewaters such as Zn-electroplating wastewater.

According to the result, 5 % FTWH effectively and inexpensively removes some heavy metal ions in electroplating wastewater (Table 5.1). Furthermore, it is a biodegradable material and also a weak acid cation exchange resin. Many of advantages for this kind of resin have been showed in the research, such as a higher regeneration efficiency (three to four higher), stable in strong oxidizing agents, low cost and saving over polystyrene bead cation exchange material. However, there are

many of applications could not used by the resin, such as softening process, salt splitting, and using in varied pH range (Table 5.2).

Table 5.1 : Summary of costs between 5 % FTWH and synthetic resin.

Cost/kg (baht)	
5 % FTWH *	Synthetic resin (Purolite)
230	360

Remark : * The cost was calculated by using the commercial grade of 5 % CH_2O and 0.4 N H_2SO_4

Table 5.2 : Comparison of advantages and disadvantages between 5 % FTWH and synthetic resin.

Properties and applications	5 % FTWH	Synthetic resin (Purolite)
1. Biodegradable material	x	-
2. High rate of regeneration	x	-
3. Matrix	hydrophilic	hydrophobic
4. Wide range of pH	-	x
5. Softenning process	-	x
6. Salt spiltting	-	x
7. Stable in any oxidizing agents	x	-
8. Low cost	x	-
9. Petrochemical product	-	x
10. Irregular shape	x	-

Finally, it could be concluded that 5 % FTWH had more efficiency for removing heavy metal ions than those of previous studies and was competitive with the synthetic resin. Moreover, it should be recommended that, all the removing of heavy metal ions from the industrial wastewater, synthetic ion exchange resin could be replaced by 5 % FTWH , according to its efficiency and friendly to the environment.

Problem and Obstructions

During the preparation of water hyacinth substrate, the portion of particular size (60 - 80 mesh) of this substrate was obtained only a small amount and spent a long time until the desired amount was obtained. In addition, there are many of samples in column experiment section, in which the personal error was mainly considered the precision of collecting effluent samples.

Recommendation

In order to repeat another studies similar to the study, several recommendations for future research are given below :

1. Combination of several heavy metal ions in synthetic solutions should be investigated for the affinity and competition of their transitional ions.
2. Transmission electron microscope (TEM) analysis and fast freeze deep-etch replication technique for testing crosslinked reaction within microfibrilla structure of water hyacinth should be investigated.
3. Varying temperature and time period on treating water hyacinth with using acidic formaldehyde should be considered.
4. Other industrial wastewaters should be studied to compare the result and find the limitation of removing for water hyacinth.
5. The catalytic digestion of the plant by using the degradation of metal loaded water hyacinth should be investigated to produce the fuel gases for domestic energy needs.

6. Formaldehyde treated water hyacinth ion exchange resin (FTWH) should be applied in the biochemistry field such as separation and purification of proteins, nucleic acids, polysaccharides, lipids, purines and pyrimidines.
7. Other plants should be investigated to compare the capacity for removing heavy metal ions.