

## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

In this study, the surfactant-modified zeolite (SMZ) was prepared from a naturally occurring zeolite, clinoptilolite, through a simple two-step surface modification technique. The resulting SMZ was examined for its ability to adsorb priority pollutants such as heavy metal and organic contaminants separately and simultaneously from aqueous phase. The regeneration of SMZ loaded with these toxic contaminants was also studied by using simple regeneration techniques to evaluate the possibility of reuse of SMZ.

The results obtained in this study clearly demonstrated that the adsorption of heavy metals such as  $\text{Cd}^{2+}$  ions and organic contaminant by natural occurring materials such as clinoptilolite was greatly improved by the simple two-step surface modification techniques which resulted in the surfactant-modified zeolite (SMZ). From the equilibrium adsorption study, the results show that pH has significant effect on the adsorption of cadmium by SMZ. The adsorption capacity of cadmium by SMZ was found to increase with increasing pH. Moreover, the results revealed an insignificant effect of ionic strength on the cadmium adsorption by SMZ, supporting the hypothesis that the adsorption of cadmium by SMZ is mainly through complexation rather than simple ion exchange. For organic adsorption, SMZ was shown to effectively adsorb organic contaminant such as toluene compared to the unmodified clinoptilolite which can be attributed to its organic partitioning phase resulted from the surface modification. In the mixed-solute systems, the presence of toluene slightly affected the cadmium adsorption by SMZ whereas the presence of cadmium was found to enhance the adsorption of toluene. The preliminary results obtained from the regeneration studies showed that the adsorbed heavy metal ions on SMZ could easily be desorbed or regenerated by an alteration of pH. On the other hand, SMZ saturated with toluene could be fully regenerated by air purging. Therefore, SMZ was shown to be a promising adsorbent for the treatment of mixed wastes containing both heavy metal and organic contaminants.

## 5.2 Recommendations

This research work focused on the preparation of the surfactant-modified zeolite (SMZ) through a simple surface modification technique and investigation of the adsorption of heavy metal and organic contaminant by SMZ at various pH and ionic strengths. In this aspect, the preparation of SMZ should be further investigated with respect to the adsorption characteristics of SMZ for both types of contaminants. Specifically, the surfactant loading and the ratio of surfactant to metal ligand should be varied. Different types of metal ligands can also be used in the preparation of SMZ.

Moreover, this work also studied the possible regeneration of SMZ after saturated with heavy metal and organic contaminant. Further investigation on different regeneration techniques such as biodegradation to completely degrade the sorbed organic compounds on SMZ should be carried out. The adsorption capacity of SMZ for heavy metal and organic contaminant after regenerated should also be examined in the subsequent adsorption cycles.