CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In the present research, selective adsorption of NH_4^+ and K^+ ions by clinoptilolite was studied using batch liquid adsorption at room temperature. The experiments were divided into 3 parts: (I) the kinetics of adsorption and desorption of NH_4^+ and K^+ ions, (II) the equilibrium of adsorption and desorption of NH_4^+ and K^+ ions, and (III) the release of NH_4^+ and K^+ ions from preloaded clinoptilolite with mixed nutrients.

From the analysis of the kinetic data, conformity to the Elovich model suggested that the adsorption and desorption of both ions were governed by a heterogeneous diffusion process. From the equilibrium studies, it was found that an increase in pH and the initial concentration of NH_4^+ and K^+ ions resulted in faster sorption and greater amounts of ions being adsorbed. In addition, K^+ ions were found to adsorb on clinoptilolite to a much greater extent compared with NH_4^+ ions.

Following the adsorption cycle, clinoptilolite samples were subjected to the desorption processes by using various cations to exchange with the adsorbed NH_4^+ and K^+ ions. In the attempt to desorbed NH_4^+ and K^+ ions sorbed on clinoptilolite, NaCl was first used as a desorbent in the study at various concentrations. It was found that quantitative amounts of sorbed NH_4^+ and K^+ ions on clinoptilolite could be desorbed, depending on salt concentration. In addition, Ca^{2+} ions had slightly greater effect on the amount of desorption than Na^+ did. Moreover, the amount of desorbed NH_4^+ and K^+ ions increase with increasing the amount of adsorbed NH_4^+ and K^+ ions.

For the last part of the experiments, the natural clinoptilolite was first loaded with NH_4^+ and K^+ ions at various loading ratios so as to examine the release of these ions. It was found that when NH_4^+ and K^+ ions were equally loaded on clinoptilolite, approximately the same amount of both ions were released from the adsorbent. In contrast, when the loading ratio of NH_4^+ and K^+ ions was relatively high, a much higher amount of sorbed K^+ ions were released, suggesting that the desorbed NH_4^+

ions may also be involved in the release of sorbed K^+. From the results obtained in this study, clinoptilolite was shown to potentially be used for the controlled release of ions such as NH_4^+ and K^+ at desired compositions from fertilizers.

5.2 Recommendations

There are some recommendations for further studies. First, the study of the release of NH_4^+ and K^+ ions from preloaded clinoptilolite with mixed-nutrients should be continued in more details. For example, kinetic study of the release of sorbed NH_4^+ and K^+ ions can be done. Various ratios of NH_4^+ and K^+ loaded on the adsorbent can be made and used in the release study. Next, the study of modified zeolite should be considered because modified zeolite might show the higher performance on adsorption and desorption of plant nutrients than natural zeolite does. Natural zeolite may be modified by either acid, basic treatment or both. Furthermore, the study of zeolite mixed with local clays should be investigated for possible cost reduction. Finally, phosphorus as the third element of plant nutrients should also be included in the future study.