CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

TEL, an organometallic compound, removal from contaminated soil by using microemulsion technique was successfully done in this study both batch and column studies. Importantly, this research demonstrated the feasibility of microemulsion formation formed by single and mixed surfactant systems to solubilize the organometallic compound, in which the studies in this area are still limited.

The beginning part of this work exhibited the oil surrogate selection to be used as the TEL surrogate due to its extremely high toxicity and difficulty to handle. The microemulsion formation between surfactant(s) and mixed oils was applied to investigate the EACN of TEL and its surrogate using the Salager's equation and a linear mixing rule. The EACN of TEL was in the range of 6.04-7.23. Several linear *n*-alkanes were found to be able to form microemulsion with the mixed surfactants systems. From the results, DBTDC mixed with decane at a molar ratio of 0.038:0.962 was found to be the most suitable TEL surrogate because the EACN of this mixed oil was closed to that of TEL.

This surrogate oil was proven to have a capability to form microemulsion with many surfactant systems including pure anionic; anionic-anionic; and anionic-nonionic surfactants systems. The supersolubilization condition, where the surfactant(s) maximizes the oils solubilization, can be investigated. Anionic surfactant binary mixture (AMA/Dowfax8390) yielded the highest solubilization of surrogate oil at the supersolubilization conditions, as a result of their micelles structures that led the surrogate oil more favorable to solubilize them. Nevertheless, an interaction between oil surrogate, DBTDC and decane, themselves was rather weak and the individual component tended to selectively solubilize regarding their affinity to the surfactant(s) as shown by a different ratio of tin (in DBTDC) and decane at pre- and post-solubilization. The stability of surrogate oil was absolutely decreased upon solubilization process even they were totally miscible when prepared.

However, the behavior of organometallic compound in surfactant(s) enhanced oil removal was not much reported at this moment, studying on the phase behavior of surfactant(s) system containing organometallic compound was very useful and challenge. Eventually, the removal of surrogate oil from contaminated soil in column study was conducted by flushing the column with microemulsion solutions. Those three surfactants systems yielded the satisfying removal efficiency in a range of 86 to 98% within 40 pore volumes, where the residual saturation of oil surrogate in the column was in the range of 12-17%. The surfactant solubilization capacity of TEL surrogate oil occurred in the column study was in good agreement with one obtained from the solubilization study in the batch experiments.

In summary, the surfactant(s) microemulsion was proven to be a promising technique to remove the organometallic compound from the contaminated soil. These findings are important information in designing an effective microemulsion system for organometallic compounds removal from subsurface in the future.

5.2 Recommendations

Even the removal of organometallic compound from soil could be achieved by a remediation using a microemulsion technique; this concept cannot totally be used to mitigate the actual problem caused by a vertical migration since TEL is a DNAPL. A selected TEL surrogate used in this study was a combination of DBTDC and decane which was in overall a light nonaqueous phase liquid (LNAPL), hence the future study should be concerned on this problem.

In the microemulsion formation and solubilization parts, the behavior of oil surrogate should be carefully noticed whether DBTDC is degraded since there was a phase transition shift. Additionally, the effect of additive added should be more considered as regarded to types of additive (salt, alcohol, etc.) and its concentration.

Furthermore, the gradient approach should be introduced to the study which is more beneficial in an economic viewpoint and potentially reduces the remedial time. In case of DNAPLs remediation, the designing of supersolubilization and gradient approach showed their ability to optimize the oil solubilization while minimizing vertical migration (Sabatini et al., 2000).