

## CHAPTER V



# CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

## 5.1 Conclusions

On the basis of the experimental results obtained, the following conclusions are for the degradation of TCE in wastewater by heat and light activated persulfate oxidation.

- 1) Effects of difference in vial positioning on system performance were determined by measuring UV intensities. Average UV intensity of the system was 10.96  $\mu$ Einstein/s. Although longer distance from lamp center led to a decrease of intensity, the variation was too small to affect the oxidation processes because of relatively constant concentrations of TCE remaining at different positions of the system.
- 2) The TCE degradation by heat and UV activated persulfate oxidation was found to follow a pseudo-first-order decay model indicated by the straight-line fit portion of the graphs ( $R^2 \sim 0.92$ ).
- 3) The system at higher persulfate/TCE molar ratio should generate more sulfate free radicals and hydroxyl radicals resulting in higher rate of TCE degradation. Appropriate persulfate/TCE molar ratios of heat persulfate oxidation system should be at least 15:1 (99.9% of 10 ppm TCE removal

and  $1.40 \text{ hr}^{-1}$  of rate constant within 5 hr) otherwise persulfate oxidation will be limited. For UV persulfate oxidation system, the persulfate/TCE molar ratios of 10:1 (99.8% of 10 ppm TCE removal and  $1.40 \text{ hr}^{-1}$  of rate constant within 5 hr) might be adequate for persulfate oxidation for degrading 10 ppm TCE.

- 4) Higher TCE concentration, in a range of 10 ppm to 100 ppm, did not affect the performances of the degradation by the heat activated persulfate oxidation system. In contrast with the UV activated persulfate oxidation system, the performances of TCE degradation were decreased when increasing concentration of TCE.
- 5) For heat persulfate oxidation at  $40^\circ\text{C}$ , persulfate concentration was the factor that limits the performance of the method. The recommended persulfate/TCE molar ratio should be at least 15:1, which could effectively degrade high TCE concentration (50 and 100 ppm), otherwise efficiency of the oxidation will be limited. For the UV persulfate oxidation system, UV intensities or lamp power was the factor limiting the performance of the method according to low efficiency of the system at optimal condition of this study for degrading TCE in high concentration – 50 and 100 ppm. The higher quantity of lamp or lamp power should yield higher efficiency.
- 6) In a case of comparison in removal efficiency, the heat persulfate oxidation system was more effective due to higher percent TCE removal and rate constant. Nevertheless, for energy consumption aspect, the UV persulfate oxidation system was more effective because of much less energy used. Energy consumption of heat persulfate oxidation at  $40^\circ\text{C}$

(62,760 kJ) was more than that of UV persulfate oxidation – 180 kJ and 9,000 kJ for electric power of 20 W and 1kW, respectively - around 150 times for 20 W UV system and 7 times for 1kW UV system comparing at 1 m<sup>3</sup> of wastewater. More treatment time led to higher required energy for both methods but higher amount of wastewater resulted in a lot of energy used for heat persulfate oxidation.

- 7) Other by-products, which were not CO<sub>2</sub>, were not detected in significant quantity. Only 2-chloroacetamide and residual TCE were detected in very low amount by GC/MS.
- 8) The efficiencies of TCE removal might be mainly derived from persulfate oxidation but the actual performance of TCE degradation might be slightly overestimated by volatilization as shown by a small decrease in blank samples (less than 8 %).

## **5.2 Recommendations for Future Work**

Based on the result of this study, it is recommended that the effects of UV intensities or lamp power on UV activated persulfate oxidation system should be studied to determine the limitation and to enhance the performance of the system. The persulfate oxidation in larger scale should be studied to determine other effects such as amount of wastewater, pH, ionic strength, and bicarbonate and other scavengers in order to determine the performance of heat and UV activated persulfate oxidation as remediation technique at contaminated sites.