

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The fractionated dissolved organic matter in industrial estate wastewater was characterized using spectrofluorometry and pyrolysis GC/MS analysis. These conclusions are based on the experimental results obtained.

1. HPOA and HPIN were the major DOM fractions in the influent wastewater and effluent water of the aeration ponds, whereas HPOA and HPIA were found to be the dominant organic fractions in the effluent water from the facultative, oxidation and detention ponds.
2. With regard to the formation of carcinogenic substances, in all water samples, the THMFP values obtained from HPOA and HPIA were found in the largest quantities compared to the THMFP values of others species. In addition, the specific THMFPs of HPOA and HPIA were considerably high.
3. The aliphatic hydrocarbon class was dominant in the influent wastewater and in the treated water. After the fractionation processes, aromatic hydrocarbon and ester were the major chemical classes of HPON; whereas carboxylic acids was the major chemical class of HPOB. Aliphatic and aromatic hydrocarbons were classified as the major chemical classes of HPOA. The chemical classes of the hydrophilic organic fractions were analyzed and aliphatic hydrocarbon was identified as the major chemical class in HPIB, HPIA, and HPIN.
4. THMs could be easily associated with hydrophobic organic fractions that are mainly composed of the aromatic hydrocarbon, ester, carboxylic acids, and phenol classes, along with the aliphatic hydrocarbon class ($C_5 \leq$ aliphatic hydrocarbon fragments $\leq C_{11}$). When aliphatic hydrocarbons ($C_{18} \leq$ aliphatic hydrocarbon fragments $\leq C_{24}$) and aliphatic organic nitrogen are combined with chlorine, they many not react and therefore fail to form THMs.
5. Tyrosine-like, tryptophan-like, and humic and fulvic acid-like substances were the major fluorescent organic matter in the influent wastewater and its treated wastewater.

6. In the case of hydrophobic organic fractions, tyrosine-like and tryptophan-like substances were classified as the major fluorescent organic matter in HPON. For HPOA, tyrosine-like and humic and fulvic acid-like substances were the major fluorescent organic matter. Regarding the hydrophilic organic fractions, tyrosine-like and humic and fulvic acid-like substances were the dominant fluorescent organic matter of HPIB, HPIA, and HPIN.
7. The aeration and facultative ponds were the main processes that reduced HPON, HPIN, HPOB and HPIB and their THMFP values. Only the aeration ponds could moderately reduce HPOA and HPIA and their THMFP values. For the total percent reduction of the DOM fractions, a combined treatment method involving the aeration, facultative, and oxidation ponds reduced HPON, HPIN, HPIB, HPOA, and HPIA by the respective values of 73%, 46%, 60%, 18% and 11%. With regard to the total percent reduction of the THMFP of the DOM fractions, the [aeration + facultative + oxidation ponds] reduced $\text{THMFP}_{\text{HPON}}$, $\text{THMFP}_{\text{HPIN}}$, $\text{THMFP}_{\text{HPIB}}$, and $\text{THMFP}_{\text{HPOA}}$ by 64%, 39%, 60%, and 34%, respectively. The $\text{THMFP}_{\text{HPIA}}$ could not be reduced by the stabilization pond process.
8. When the FEEM was used to evaluate the reduction of fluorescent organic matter, the aeration ponds were identified as the main process for reducing tyrosine-like, tryptophan-like, and humic and fulvic acid-like substances. They reduced the tyrosine-like substances at peaks A and B, and tryptophan-like substances at peaks C and D by 88 and 52%, and 43 and 39%, respectively. Decreases of only 20 and 18 percent of the humic and fulvic acid-like substances at peaks G and H were observed in the aeration ponds. Total percent reductions of total fluorescent organic matter from the aeration ponds, facultative ponds, and oxidation ponds were 46, 51 and 54%, respectively. These values were significantly similar to the total percent reduction of DOC by the respective processes at 54, 53, and 55%, respectively.

8.2 Contributions of this work

This research is one of the first to apply resin fractionation, pyrolysis GC/MS, and three-dimensional fluorescent spectroscopy to investigate the major DOM fractions, major THMs precursor, chemical classes of DOM fractions, and the putative origins of fluorescent organic matter of DOM fractions in industrial estate wastewater and its treated wastewater. The water samples all came from the Northern-Region Industrial Estate, Lamphun province, Thailand, where treated wastewater will be used as raw water for water supply plant. The information from this work will be useful to both academics and the study site. Firstly, it was proven that THMFP values obtained from HPOA and HPIA had been found to be in the largest quantities in industrial estate wastewater and its treated water. In addition, the specific THMFPs of HPOA and HPIA were considerably high. This was due to the high percent distributions of the aliphatic and aromatic hydrocarbons classes in HPOA and the aliphatic hydrocarbon class in HPIA. These two fractions, therefore, should be removed from treated wastewater prior to it being disinfected with chlorine in the water supply plant. More research should be directed towards finding a suitable treatment technique for the reduction of these two fractions that focuses on the removal of the aliphatic and aromatic hydrocarbon classes. Furthermore, the identification of chemical classes in DOM fractions that could potentially lead to the formation of THMs, such as the aromatic hydrocarbon, carboxylic acids, phenol, ester, and aliphatic hydrocarbon ($C_5 \leq$ aliphatic hydrocarbon fragments $\leq C_{11}$) classes, will be useful as a starting point for the future evaluation of the reaction mechanism between these chemical classes and chlorine to form DBPs. Finally, the FEEM results from this work suggest that each DOM fraction has its own FEEM signature. The development of a computer modeling program to predict the DOM fractions using FEEM analysis may enable engineers to install an online monitoring device that could help to manage and control the level of carcinogenic substances in a produced water supply.

8.3 Recommendations for Further Work

The distributions of the DOM fractions, THMFP, specific THMFP, chemical classes and pyrolysis fragments, and the compositions of the fluorescent organic matter of the DOM fractions were successfully identified in this study. Accordingly, the performance capabilities of the stabilization ponds for reducing DOM and DOM fractions were also

evaluated. However, this evaluation is far from being complete; further work should be conducted on the following:

1. The reaction mechanism between chemical classes of DOM and chlorine to form DBPs.
2. The biotransformations of each DOM fraction and pyrolysis fragment from each chemical class in the aeration, facultative, oxidation and detentions ponds.
3. The potential of using three-dimensional fluorescent spectroscopy analysis for quantifying the concentrations of problematic DOM fractions and fluorescent organic matter, i.e., tyrosine-like, tryprophan-like, and humic and fulvic acid-like substances.
4. Identifying the water treatment process capable of removing major DOM fractions along with aromatic hydrocarbons, carboxylic acids, and phenols.