CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary of research

The overall perspective of this research was to investigate the haloacetic acids (HAAs) formation and their precursors in the Bangkhen Water Treatment Plant (Bangkhen WTP). The findings could be summarized as follows (note that the results were subject to the quality of the water in the Bangkhen WTP during Mar – Aug 2003):

1. DOC of the water sample was found to be in the range of 2.78 – 4.73 mg/L and SUVA values generally varied from 1.502 - 2.774 L/mg-m.

2. The sequence of the quantities of the six organic fractions in order from largest to smallest was: hydrophilic neutral (30 - 45% by weight) > hydrophobic acid (20 - 40% by weight) > hydrophilic acid (8 - 20% by weight) > hydrophobic neutral (6 - 15% by weight) > hydrophilic base and hydrophobic base (each at 1 - 7% by weight).

3. The fractionation procedure resulted in approximately 0.1 - 9% weight surplus of organics compared with the total organic carbon content of the original pre-fractionated sample.

4. Based on the sequence of the total HAAFP of each organic fraction, it was found that the hydrophilic neutral fraction (134.51 μg/L) was presented in the highest quantity, hydrophobic acid (71.78 μg/L) the second, followed by: hydrophilic acid (32.01 μg/L), hydrophobic base (27.00 μg/L), hydrophilic base (22.29 μg/L), and hydrophobic neutral (16.60 μg/L), respectively.

5. The observed specific HAAFP which indicated the reactivity of each organic species with chlorine was found to be the highest in the hydrophobic

organic base fraction (207.69 μgHAAs/mgDOC), followed by hydrophilic base (139.31 μgHAAs/mgDOC), hydrophilic neutral (63.45 μgHAAs/mgDOC), hydrophobic neutral (61.48 μgHAAs/mgDOC), hydrophobic acid (44.31 μgHAAs/mgDOC), and hydrophilic acid (38.11 μgHAAs/mgDOC), respectively.

6. Only three forms of HAA species, i.e. monochloroacetic acids (MCAA), dichloroacetic acids (DCAA), and trichlroacetic acids (TCAA) were found in this water source.

7. Good linear correlations could be obtained between HAAFP of individual organic fraction and UV, DOC, and chlorine demand (R^2>0.96) .

8. Based on the result obtained from FTIR analysis of the pre- and post-chlorinated water samples, the possible target functional groups associated with the formation of HAAs were carboxylic acids, aromatic characteristics, amide, amino acids, and ketones.

9. In the single-component experiment, it was evidenced that DCAA was the predominant species in most of the chlorinated fractions, followed by MCAA and TCAA, respectively.

10. Contradictory results were revealed in the multi-component mixtures where MCAA was the major species and DCAA had a higher concentration than TCAA.

11. In the examination of the HAA formation from the multi-component mixtures of six organic fractions, HPOB and HPIB fractions played an important role in supporting the formation of HAAs whereas HPOA and HPIA fractions had an inhibiting effect when they were present in mixture components.

7.2 Contributions

This research was one of the first that applied the fractionation technique to investigate the HAA formation potential and to identify their precursors in the water distribution system in Thailand. In fact, this was among the first attempts that reported the HAAFP generated from the source water used in the production of potable water for a majority of people in Bangkok. The results revealed that there was risk associated with the uses of this water and appropriate standards should be set in controlling this parameter in the potable water. The information from this work will be useful in both academic and application points of view. Firstly, the identification of functional groups in the organic species that could potentially lead to the formation of HAAs will be useful as a starting point for the future evaluation of the reaction mechanism of DBPs. In addition, this will facilitate the future management for the design of controlling techniques to prevent the formation of DBPs. Next, the development of the predictive modeling tool associated with HAAs formation may enable engineers to install an online monitoring device in the control loop of the future treatment techniques that minimizes the generation of undesirable DBPs.

7.3 Recommendations for future work

Based on the experience gained in this study, the target problematic precursors of HAAs formation in the Bangkok water distribution system became clearer. However, the results were still obtained from a limited number of water samples and no results were given regarding the control of such precursors. Therefore the following future works are recommended:

1. A variety of uncontrolled environmental conditions, e.g. seasonal variation, temperature, etc., to the formation of HAAs should be included in the study.

2. Further study should be conducted towards the method of minimizing and reducing HAAs and perhaps other DBPs. For instance, the management strategy should be thoroughly formulated in order to minimize the chance of having high organic contents which will eventually lead to DBPs formation (including HAAs). In addition, the methods of controlling the formation of DBPs from the chlorination process such as coagulation, etc. should be promptly investigated.

3. The drinking water standard in Thailand should include the regulations for HAAs (and other DBPs). This standard should be based on the

compromises between the available treatment efficiency obtainable from the distribution systems in Thailand and the existing level of organic contaminants.