CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The ultimate goal of this study was to determine the efficiency of nanofiltration using three types of membranes (ES 10, NTR 7410, and NTR 729 HF) and ozonation-BAC treatment processes for HAA_5 removal. The study also investigates the operating variables that could affect the performance of both treatment processes. From the results observed during the studies, several conclusions can be made:

1. Nanofiltration would be an effective technique to remove HAA_5 when using a membrane having both small pore size and a negative surface charge (e.g., ES 10 and NTR 7410). To obtain the satisfactory HAA_5 removal (more than 80% reduction), NF membrane must retain both properties. A neutral NF membrane (*e.g.*, NTR 729HF) is not be a good candidate to remove HAA_5.

2. The operating pressure and concentration of HAA_5 in feed water are two variables affecting the performance of the NF membranes. Cross-flow velocity showed relatively low effect on the performance of all membranes. However, these effects were less pronounced with ES 10.

3. For ES 10, the electrostatic repulsion (Donan effect) between HAA_5 anions and the negative surface charge of the membrane equally worked with the sieve effect in regulating the performance of the membrane. However, for NTR 7410 and NTR 729HF, the Donan effect is more important.

4. The acid dissociation property of the individual HAA_5 species is the major characteristic governing its rejection by the NF membrane. HAA_5 species with high pK_a values (*e.g.*, DCAA and TCAA) are better retained than those with lower pK_a. This could due to the recent finding that a compound with low pK_a value shows the better capability to exchange with water molecules in the membrane matrix. Therefore, it has more potential to move across the membrane.

5. HAA_5 removal efficiency of the ozonation process is considerably low (10-20% reduction), suggesting that ozonation is not an attractive approach for controlling

HAA_5. Both ozone dose and contact time have insignificant effect on the reaction between HAA_5 and dissolved ozone.

6. Among five HAA species, CAA and BAA are more susceptible to ozonation process than the others

7. During the ozonation process, HAA_5 react directly with dissolved ozone rather than OH radical. The reaction rate is relatively low due to electron withdrawing property of chlorine, bromide and carboxylic functional groups on the molecule of haloacetic acids. Therefore, use of ozonation as a pretreatment process is considered unnecessary.

8. Biofiltration using a BAC column is another good candidate method for controlling HAA_5. The complete removal of HAA_5 is observed in nearly all test conditions.

9. NF and BAC are equally effective in removing HAA_5 at the concentrations of 60-90 ppb. At a higher concentration of 120 ppb, BAC apparently works better. Between NF and BAC, the former technique physically removes HAA_5 without any alteration. Additional treatment will be needed to further treat the retentate that would concentrate with HAA_5. BAC, on the other hand, transforms the acids into more benign products. Therefore, further treatment is not required

5.2 Recommendations

Several promising results have been found during this study. However, like any new findings, additional research is necessary to sharpen the obtaining data. Recommendations for future studies are presented as follows:

1. Although ES10 membrane proved to be the most effective membrane in removing HAA_5, NTR 7410 also exhibited the performance in a satisfactory level (over 80% removal). Since NTR 7410 has a larger pore volume, it gives higher permeate flux than dose ES 10. In a large scale water production system, HAA_5 removal by nanofiltration using NTR 7410 would consider more economical than using ES 10 which provides smaller amount of permeate flux.

2. study the effect of residue chlorine on HAA_5 rejection of nanofiltration membrane ES 10.

3. investigate the effect of feed water pH on the removal of HAA_5 by nanofiltration membranes.

4. identify the maximum concentration of HAA_5 that can be removed by BAC.

5. inoculated GAC with bacteria already available in the drinking water distribution system and observed their effectiveness in removing HAA_5.