CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The results from the study of the effects of silica fouling on fluoride removal by an ultra low pressure reverse osmosis membrane can be concluded as follows:

1. Permeate fluxes were observed in both the concentration polarization experiment and the membrane fouling experiment. The solution-diffusion flow model was used to explain the relationship between the permeate flux and the transmembrane pressure. The highest transmembrane pressure at 0.5 MPa resulted in the highest permeate flux and the shortest operating time. It was found that water flux increases linearly with operating pressure. In the membrane fouling experiment, it was observed that the permeate flux declined, while the silica concentration in feed water increased due to the accumulation of silica in the feed water on the membrane surface.

2. In the concentration polarization experiment, the mass transfer coefficient (k) was calculated. It was found that the average k values of NaF at 0.1, 0.3, and 0.5 MPa were 4.79×10^{-5}, 4.12×10^{5}, and 3.24×10^{-5} m/s, respectively.

3. The results of the concentration polarization phenomenon indicated that the concentration of NaF on the membrane surface (C_M) was higher than that of the bulk solution (C_B), leading to an increase in the intrinsic rejection rate (R_{int}) which is higher than the observed rejection rate (R_{obs}).

4. The percentages of fluoride rejection were observed during membrane fouling. It was found that the percentages of fluoride rejection at 0.1 MPa were 87.0-96.1%, whereas those at 0.3 MPa were 94.9-98.7% and at 0.5 MPa were 95.1-98.8%. However, defluoridation efficiency levels of between 87.0 and 98.7 % were obtained by using the ULPRO membrane.

5. At 0.3 and 0.5 MPa, the formation of a polymerized silica fouled layer occurred at a low silica concentration of 100 mg/L, whereas the formation of colloidal silica fouled layer appeared at a high silica concentration of 300 mg/L. At 0.1 MPa, the polymerized silica fouled layer was found at both the low silica concentration and high silica concentration. The polymerized silica fouled layer, dense-gel layer, acts as a second filtration layer for solute rejection. Hence, the fluoride rejection rate increased at low silica concentration feed solution. However, the colloidal silica fouling formed loose-gel layer which provides a lesser back diffusion of solute from the membrane surface to the bulk solution. The fluoride rejection dropped slightly at the high silica concentration feed solution.

5.2 Recommendation for the management of defluoridation of the RO membrane plant in Lamphun province

The results obtained in this study could be applied for groundwater defluoridation of the existing membrane plants operated in Lamphun area are as following recommendation.

As mentioned earlier in chapter 2, it was reported that the average concentration of silica (SiO_2) of 28 mg/L present in groundwater of some areas of Lamphun province. In addition, the existing defluoridation membrane plants in such area are not employed with silica (SiO_2) pretreatment unit. So as to avoid the membrane problem due to the silica fouling, the strong-base anion-exchange resin unit for silica removal is recommended to add in the pretreatment process of typical defluoridation membrane plant which consist of only a sand filtration tank (Sand Filter), a granular activated carbon adsorption tank (GAC Filter), and cation exchange reactor (CER Reactor).

5.3 Recommendations for future research

Generally, the solubility of amorphous silica is about 100 – 120 mg/L at neutral pH and temperature of 25 °C which were the controlled conditions of experiments in this study. However, the solubility of silica in water is varied depending on pH, temperature and the presence of other substances. Thus, the effects of pH and temperature on solubility of silica in water resulting in the formation of silica gel layer on membrane surface are recommended to be investigated. Moreover, further research on chemical cleaning for silica fouled membrane is also required.