CHAPTER I

INTRODUCTION

1.1 Motivations

Membrane filtration technology for municipal water and waste water treatment has been widely spread all over the world, and the installation of microfiltration (MF) and ultrafiltration (UF) facilities has dramatically increased over the past decade (Adham *et al.*, 2005). Membrane filtration is considered as a promising process to provide better drinking water quality for water supply. Especially, microfiltration (MF) and ultrafiltration (UF) membrane applications are receiving increased attention associated with water quality and cost reduction b improvements in membrane technology (Sangyoup *et al.*, 2004).

Historically, the use of MF and UF for water and wastewater treatment has been almost exclusively focused on polymeric membranes (Van der Bruggen *et al.*,2003). Most polymeric membrane systems operate well within a fairly neutral to slightly acidic pH range, with prolonged extreme acidic or alkaline conditions posing potential problems (Farahbakhsh *et al.*, 2004). Furthermore, exposure to extreme oxidant conditions created by chlorine and ozone can cause degradation of polymeric membranes (Castro *et al.*, 1995). As a result, innovative MF/UF membranes are currently being developed to improve pore distribution, mechanical stability, and chemical stability, using optimized polymeric formulations or alternative materials (i.e., ceramics, steel, polytetrafluoroethylene, etc.).

Material that shows promise in addressing the current challenges of conventional polymeric membranes is ceramics. It is well known that ceramic membranes have the combined advantage of high mechanical strength, stability for chemical, high permeability, thermal resistance and long service life. Moreover, the ceramic membranes exhibited higher permeability than the equivalent polymeric membranes (Lee S. *et al.*, 2004). For this reason, many companies and research institutes have been working on the development of ceramic membranes for several years. Membrane processes can potentially shorten treatment chains by eliminating coagulation, flocculation and sedimentation, and have become attractive technology to consider as a substitute for conventional drinking water treatment (Lee N. *et al.*, 2004; Xia *et al.*, 2004). However, ceramic membrane is MF and UF whose pore size is not sufficiently small to reject particles smaller than some 10 nm, such as DOMs and viruses.

Dissolved organic matter (DOM) is a complex mixture of various compounds with widely different chemical properties from simple structure to very complex polymers in natural. Generally, natural water source such as river, reservoir and groundwater, are utilized as the source of raw water to produce water supply. DOMs in natural water could potentially react with chlorine during the disinfection process in the typical water treatment facility and formed disinfection by-products (DBPs) such as trihalomethanes (THMs), haloacetic acids (HAAs) and other halogenated organics which are classified as carcinogenic substances (Rook *et al.*, 1974; Reckhow *et al.*, 1990) Since THMs are classified as potentially carcinogenic substances, the U.S. Environmental Protection Agency (USEPA) has issued drinking water standards under the Disinfectants/Disinfection By-Products (D/DBP) Rule. Under this rule, the Maximum Contaminant Levels (MCL) for THMs are 80 μg/L for Stage 1 and 40 μg/L for Stage 2 (USEPA, 1998).

Therefore, many efforts have been made to characterize DOM in order to improve its removal and reduce DBPs formation during water to determine treatment process selection and applicability (Croued *et al.*, 2004). Conclusive results from past research showed that the major surrogate parameters for representing the level of DOM in water and wastewater are Dissolved Organic Carbon (DOC), Ultraviolet absorbance at wavelength 254 nm (UV-254), Specific Ultraviolet Absorption (SUVA) and Trihalomethanes Formation Potential (THMFP) (USEPA, 1999). Fluorescent Excitation-Emission Matrix (FEEM) could be used to classify the complex composition on the putative origin of the fluorescent organic matter in water and it may identify the matter as a tyrosine-like substance, tryotophan-like substance, humic and fulvic acid-like substance, and so on (Coble 1996; Nakajima *et al.* 2002; Chen *et al.* 2003; and Sierra *et al.* 2005). It has the advantage of its simplicity due to its minimal sample amount, pretreatment and analysis time requirements. Therefore, it must be useful to evaluate the fluorescent DOM removal by coagulation combined with ceramic membrane filtration processes considering in the peak intensities at their peak position of FEEM.

In addition, DOM can be characterized on the basis of its apparent molecular weight (AMW) by using ultrafiltration. Amy *et al.* (1987) described the procedure using a series of hydrophilic ultrafiltration membranes. That approach yielded a series of corresponding permeated for analysis with the following AWW ranges: < 500 Daltons, < 1,000 Daltons, < 3,000 Daltons, < 5,000 Daltons, < 10,000 Daltons, < 30,000 Daltons. Another method that is commonly used to characterize NOM according to the AMW is gel permeation chromatography (GPC). GPC can be used to chromatographically separate large and small amounts of DOM. The size separation of DOM is dependent upon the types of gel. For example, a Sephadex G-75 gel is capable of size separation in the range of approximately 1,000 to 50,000 Daltons (AWWA, 1993).

As described above, the size separation of DOM distribute from 500 to 50,000 Daltons, but the Molecular Weight Cut Off (MWCO) of MF and UF are in range 100,000-1,000,000 Daltons. As a result, the removal of DOM through the conventional membrane filtration is based on the sieving mechanism alone, the amount of DOM residual in treated water is still of problematic concern. The one process that basically applied to enhance the permeate quality from membrane filtration would be coagulation/ flocculation process. Therefore, it is suggested that a coagulant be added before membrane filtration, not only in order to improve the effectiveness of the removal of DOM but also to reduce fouling, especially irreversible fouling (Pikkarainen *et al*, 2003). In this study, In-line coagulation was the selected applicability to promote flocs formation prior to ceramic membrane filtration that may enhance the solid-liquid separation onto the membrane surface.

The previous researches concerned on membrane filtration technology not only focused on DOM removal but also interest on the virus removal to evaluate filtrate quality in term of risk assessment to human health.

Human enteric viruses have been recognized as major cause of waterborne outbreak which has been reported worldwide in both developed and developing countries (Hoebe *et al.*, 2004; Boccia *et al.*, 2002; Subekti *et al.*, 2002). The numbers of enteric viruses presented in surface waters are generally few and difficult to identify and isolate. Therefore, the basic steps of virological analysis of environmental waters are consisted of sampling, virus concentration and detection.

The methods to detect pathogens are relatively laborious, require specialized personnel, and not well suited for monitoring purpose. Therefore, the interest was focused on indicator organisms that are nonpathogenic, rapidly detected, easily enumerated, similar survival characteristics to those of the pathogens and able to associate with the presence of pathogenic microorganisms.

The bacteriophages (bacterial viruses) have been proposed as useful alternative viral indicator, as their morphology and survival characteristics closely resemble that of some of the important human virus groups. Several researches have been published on the use of bacteriophages as viral indicators for the presence of human enteric viruses in fresh water, fecal pollution of treated or untreated drinking water, or indicators of treatment efficiency.

In order to evaluate the filtrate water quality through the viral indicators, three types of bacterial host strain named *E. coli* WG5, *E. coli* K12 and *Salmonella typhimurium* WG 49 were used for somatic coliphages enumeration and F-specific RNA bacteriophages enumeration.

This research discussed results of lab-scale studies designed to investigate ceramic membrane filtration technology for natural water treatment, focusing on DOM removal. Another parameter induced to evaluate filtrate quality will be viral indicator (bacteriophages and coliforms). Furthermore, the combination of In-line coagulation using PACl as coagulant prior to membrane filtration will be demonstrated.

1.2 Objectives:

- To evaluate the removal of DOMs in natural water by In-line PACl coagulation combined with ceramic membrane.
- To investigate THMFP reduction by In-line PACl coagulation combined with ceramic membrane filtration.
- To introduce a Fluorescent Excitation-Emission Matrix (FEEM) technique for DOMs characterization and DOMs reduction by considering the reduction of peak intensities of FEEM to evaluate the fluorescent DOM removal by In-line PACl coagulation combined with ceramic membrane filtration.
- To evaluate the removal of total coliform, *E. coli*, and bacteriophages in natural water by In-line PACl coagulation combined with ceramic membrane filtration.

1.3 Hypotheses:

- In-line coagulation process prior to ceramic membrane filtration may enhance DOMs removal efficiency.
- Bacteriophages may be inactivated and adsorbed on to PACl particles, which can be retained by ceramic membrane to form cake layer.

1.4 Scopes of the Study:

- Water from Ping River and Aung-Keaw Reservoir were selected as water samples.
- PACl was used as coagulant of In-line coagulation prior to 1.0μm, MF (0.1μm) and UF (0.01μm) ceramic membrane filtration. PACl dosage was varied to find the optimal dose.
- Conventional Jar Testing was performed to compare the removal efficiency with In-line coagulation prior to ceramic membrane filtration.
- DOM surrogates (DOC, UV-254, FEEM and THMFP) were analyzed to determine water quality.
- Fluorescent excitation-emission matrix (FEEM) was utilized to characterize the fluorescent organic matter of the DOMs.
- Total coliform, *E. coli*, and bacteriophages and were detected to evaluate filtrate quality.
- *E. coli* K12 A/λ (F+), *E. coli* WG5, and *Salmonella typhimurium* WG 49 were used as bacterial host for somatic coliphages enumeration and F-specific RNA bacteriophages enumeration.