CHAPTER I

INTRODUCTION

1.1 Motivations

Wastewater and treated wastewater attribute to the major allochthonous dissolved organic matter (DOM) in drinking water sources (i.e., groundwater sources, rivers and, reservoirs and lakes). DOM in water sources is of particular concern because DOM can react with the chlorine used in the disinfection process and form potentially harmful disinfection by-products (DBPs) such as trihalomethanes (THMs), haloacetic acids (HAAs), and haloacetronitriles (HANs). 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).

Past research conclusively reported that the characteristic of the DOM was one of the most important parameters influencing THM formation. For example, hydrophobic base (HPOB) DOM was highly reactive with chlorine in forming THMs, while hydrophilic neutral (HPIN) DOM was one of the most inactive organic precursors of THMs (Marhaba and Van, 1999; and Panyapinyopol *et al.*, 2005). Harrington *et al.* (1996) and White *et al.* (2003) proposed that pyrolysis fragments of phenol classes were found as the best indicator of chlorine reactivity. Phenol correlated well with chloroform formations (Harrington *et al.* 1996). The THMs and total organic halides (TOX) formation were observed to be related to the organic nitrogen content that expressed the presence of proteins and/or elevated algal content (Reckhow *et al.*, 1990; Scully *et al.*, 1988; Gehr *et al.*, 1993; and Young and Uden, 1994). Sirivedhin and Gray (2005) found that the combination of aromatic and aliphatic structures including some substituted with nitrogen and chlorine had a linear relationship with the disinfection by product formation potential (DBPFP).

There are two approaches for identifying the characteristics of DOM in water. Firstly, DOM has been commonly quantified by using surrogate, nonspecific parameters such as total organic carbon (TOC), dissolved organic carbon (DOC), ultraviolet absorbance at a wavelength of 254 nm (UV- 254), and trihalomathane formation potential (THMFP) (USEPA, 1999). Secondly, for a more complicated approach, resin fractionation can be used to isolate bulks of DOM into DOM fractions that are chemically similar (AWWA, 1993). Three-dimensional fluorescent spectroscopy (fluorescent excitation-emission matrix, FEEM) provides information on the putative origin of the fluorescent organic matter in water. 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). In order to identify the nature and abundance of structural units in DOM molecules, element composition analysis, ^{13}C- and 1H-neuclear magnetic resonance (NMR) spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, and pyrolysis gas chromatography mass spectrometry (pyrolysis GC/MS) have been employed. Among theses methods, pyrolysis GC/MS seems to be one of the most advanced techniques commonly in use. Pyrolysis GC/MS provides information on the pyrolysis fragments of the chemical classes of DOM in water. Pyrolysis GC/MS, therefore, has been used by many researchers to characterize the chemical classes in river water (Bruchet *et al.* 1990 and White *et al.* 2003), lake water (Biber *et al.* 1996; and White *et al.* 2003), groundwater (White *et al.* 2003), treated wastewater (Dignac *et al.* 2000; and Sirivedhin and Gray, 2005) and untreated wastewater (Dignac *et al.* 2000).

The Northern-Region Industrial Estate is the largest industrial estate in northern Thailand, hence it utilizes a considerably high quantity of approximately 14,000 m^3 of produced water per day. During the dry season that begins in late February and ends in the early part of June, water shortage problems have occurred in the study area. The industrial estate, therefore, initiated a plan to draw about 12,000 m^3/day of treated wastewater from the stabilization ponds, which consists of aeration, facultative, oxidation and detention ponds, into their raw water supply reservoir for use as raw water for their water supply plant. While relieving one problem, this action may cause another since DOM in the treated wastewater could react with the chlorine used in the disinfection process of the water treatment plant and form THMs (Musikavong *et al.* 2005). THMs could adversely affect the workforce of the industrial estate who utilizes the produced water supply as drinking water.

In general, the characteristics of DOM in treated wastewater mainly depend upon the characteristics of the DOM in the influent wastewater and the performance capability of the wastewater treatment plant in reducing DOM. Previous reports demonstrated that DOM characteristics such as DOC distribution, THMFP, chemical classes, pyrolysis fragments, and the composition of fluorescent organic matter of DOM fractions in industrial estate wastewater and treated effluent by stabilizations ponds had not been widely evaluated. Accordingly, the performance capability of stabilization ponds in reducing DOM and DOM fractions in industrial estate wastewater has also not been extensively investigated. Therefore, in this study we chose to isolate the DOM in the influent wastewater and effluent water from the aeration, facultative, oxidation and detention ponds of the central wastewater treatment plant of the selected industrial estate by the resin adsorption method and to investigate the THMFPs of the DOM fractions. In addition, the chemical classes and prominent pyrolysis fragments of DOM in the influent wastewater and in the treated effluent of each pond, along with their DOM fractions were identified. Three-dimensional fluorescent spectroscopy was utilized to evaluate the fluorescent organic matter of DOM and DOM fractions in the influent and effluent water of each pond. Finally, the performance capability of the stabilization ponds in reducing DOM and DOM fractions was investigated.

1.2 Objectives

- To investigate the DOC mass distribution, THMFP and specific THMFPs of the DOM fractions in industrial estate wastewater and effluent water from the aeration, facultative, oxidation and detention ponds.

- To identify the common fragments, prominent major fragments, specific fragments and chemical classes of DOM and DOM fractions in industrial estate wastewater and effluent water from the aeration, facultative, oxidation and detention ponds.

- To scrutinize the fluorescent organic matter of DOM and DOM fractions in industrial estate wastewater and effluent water from the aeration, facultative, oxidation and detention ponds.

- To evaluate the performance capability of the stabilization ponds in reducing DOM and DOM fractions.

1.3 Scope of Study

- Influent wastewater and effluent water from the aeration, facultative, oxidation and detention ponds of the central wastewater treatment plant of the Northern-Region Industrial Estate were selected as water samples.

- A fractionation method, the resin fraction technique developed by Leenheer (1981) and Marhaba *et al.* (2003), was utilized.

- A pyrolysis GC/MS was used to identify the chemical classes and pyrolysis fragments of the DOM and DOM fractions.

- Three-dimensional fluorescent spectroscopy was utilized to characterize the fluorescent organic matter of the DOM and DOM fractions.