CHAPTER I

INTRODUCTION AND OBJECTIVES

1.1 Background and Motivation

Over the last decade, the presence of endocrine-disrupting chemicals (EDCs) in municipal wastewaters and surface waters has raised extensive concerns with respect to their potential impact on aquatic ecosystem (Routledge et al., 1998) and human health. This is particularly true for natural steroidal estrogen hormones which are excreted daily by humans and livestock through feces and urine which eventually will end up in the environment.

Natural estrogens found in wastewaters include estrone (E1), 17β-estradiol (E2), and estradiol (E3). Of the three compounds, E2 has the highest estrogenic activity (Khanal et al., 2006) and is always present in municipal wastewaters (Matsui et al., 2000). E2 concentrations in wastewater influents typically ranged from a few ng/L to 100 ng/L. The presence of E2 even at a concentration of 5 ng/L has been shown to induce female-specific proteins (F_{sp}) in mature male fish (Medaka species) (Tabata et al., 2001). Since natural estrogens in wastewaters can not be completely eliminated, studies have been conducted to understand the operating conditions and type of treatment processes that would maximize estrogen removal.

In biological wastewater treatment, E2 are known to be removed through adsorption onto the biomass or biofilm followed by subsequent degradation by microbes within the biomass/biofilm (Khanal et al., 2006). Significant removal of E2 has been found in the presence of nitrifiers which have been shown to have estrogen removing capability (Vader et al., 2000). Long solids retention times (SRTs) of the treatment plant also tend to give better removal of E2 due to longer exposure which is favorable for the effective adsorption and degradation (Ternes et al., 1999a). In addition, wastewater treatment systems with high mixed liquor suspended solids (MLSS) may result in higher sorption of E2 (Ren, 2007; Kikuta and Urase, 2003). It is possible that attached growth (biofilm) systems with longer SRT and the presence of nitrification may improve removal of E2 from wastewaters and therefore better removal. However, not much is known about the fate of estrogenic compounds in attached growth aerobic and anaerobic systems.

Although estrogens are not currently regulated, many wastewater treatment plants will be required to limit their discharge of phosphorus and nitrogen. Excess phosphorus and nitrogen discharge, especially of anthropogenic origin, results in eutrophication of lakes and rivers. In order to reduce such pollution, the requirements for nutrient discharge are becoming more stringent. The European Commission Urban Wastewater Directive stipulates that total phosphorus and nitrogen concentration in treated wastewater should be less than 2 and 15 mg/L, respectively. In the US, the discharge limit is dependent on the watershed and, for example in California, the limit is regulated at 2 mg/L for phosphorus and 9 mg/L for nitrate as reported by Wang et al. (2006). At severely impaired watersheds, the total phosphorus level can be set as low as 1 mg/L.

Many wastewater systems have applied enhanced biological phosphorus removal (EBPR) for the removal of phosphorus in municipal wastewaters. One of the newer technologies being developed to minimize the tankage is by using alternating packed bed filters where the bed filter conditions are switched from anaerobic to aerobic and vice versa to remove phosphorus. These biofilters can retain high phosphorus accumulating biomass which may have several advantages in phosphorus removal over conventional suspended growth systems (Pak and Chang, 2000). In addition, alternating filters can be compact with a small footprint which will be useful for small wastewater treatment systems. Although alternating filters are being developed to remove phosphorus, there is a possibility that estrogenic compounds may not be optimally treated in one of the cycles. In addition, under certain operating conditions which are optimized for COD and phosphorus removal, estrogen removal may not be optimized.

1.2 Objectives

This study focuses mainly on the removal of E2 and phosphorus from wastewater in alternating attached growth filters under anaerobic/aerobic conditions. The objectives of this study are as follows:

- To investigate E2 and phosphorus removal for various hydraulic retention times (HRTs) and nutrient loadings on the alternating filters.

- To assess the dominant removal process in alternating filters by using mass balances and batch sorption studies of E2.

1.3 Hypotheses

- E2 and phosphorus can be removed from the wastewater using alternating attached growth filters under anaerobic/aerobic conditions.
- HRT and nutrient loading impact the performance of the biofilters which may enhance or inhibit E2 and phosphorus removal.
- Nitrification, long SRT, and high SS of the alternating system can effectively remove E2.
- E2 are mainly removed from the aqueous phase by adsorption onto biofilm.

1.4 Scope of Study

- Alternating attached growth filters enriched with phosphorus accumulating organisms (PAOs) will be grown using synthetic wastewater.
- The study will focus on E2 and phosphorus removal for different operating conditions.
- Seed sludge will be taken from a municipal wastewater treatment plant.
- Study will be carried out in laboratory-scale continuous flow reactors.
- Adsorption isotherm will be determined in batch sorption experiments.

1.5 Organization of Thesis

The thesis is organized into five chapters with the introduction and literature review in Chapter 1 and Chapter 2, respectively. Chapter 3 outlines the experimental methods and materials used while Chapter 4 contains the results and discussion. The overall conclusions and suggestions for future work are presented in Chapter 5. The data for all the experiments are presented in Appendix A to C.