Chapter 4
Removal of Emerging Contaminants from Water and Wastewater Using Nanofiltration Technology

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ABSTRACT

Conventional water/wastewater treatment methods are incapable of removing the majority of Emerging Contaminants (ECs) and a large amount of them and their metabolites are ultimately released to the aquatic environment or drinking water distribution networks. Recently, nanofiltration, a high pressure membrane filtration process, has shown to be superior to other conventional filtration methods, in terms of effluent quality, easy operation and maintenance procedures, low cost, and small required operational space. This chapter provides a comprehensive overview of the most relevant works available in literature reporting the use of nanofiltration for the removal of emerging contaminants from water and wastewater. The fundamental knowledge of nanofiltration such as separation mechanisms, characterization of nanofiltration membranes, and predictive modeling has also been introduced. The literature review has shown that nanofiltration is a promising tool to treat ECs in environmental cleaning and water purification processes.

1. INTRODUCTION

Emerging contaminants (ECs) can be broadly defined as any synthetic or naturally occurring chemicals but cause known or suspected adverse ecological and(or) human health effects. This ever-increasing contaminants pose potential environmental and health threat to the living organism (Bolong, Ismail,

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Salim, & Matsuura, 2009). In some cases, due to low concentration emerging contaminants have likely existed for a long time, which may not be detected until new analytical methods are developed. Hence, some ECs are not necessarily new chemicals, which are from municipal, agricultural, and industrial wastewater sources and pathways (Petrović, Gonzalez, & Barceló, 2003).

There are two reasons why emerging contaminants are of continued concern for the health and safety of consuming public. The first one is the trace level of most ECs with concentration at μg/L or ng/L, and broad range of physiochemical characteristics, which make both detection and elimination extremely difficult (Richardson & Ternes, 2005); And the second one is the adverse health and environmental effects of ECs even at a low concentration. Some intermediate metabolites or transforming products of ECs (especially for endocrine disrupting chemicals) exhibit biologically active effect as well (Diamanti-Kandarakis et al., 2009).

The main issue of ECs is nonexistence of limiting regulations, especially for new compounds, by-products, pharmaceuticals as related to the water and wastewater treatment industry. The first Contaminant Candidate List (CCL) was created in 1998 by United States Environmental Protection Agency (US EPA) for contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations. Even through many efforts have been devoted, there is limited number of contaminants with Maximum Contaminant Level (MCL) regulated by US EPA.

The main groups of ECs are described in Table 1.

As most ECs are small organic molecules, most conventional water treatment processes exhibit ineffective removal of emerging contaminants. Given the variety of emerging contaminants, advanced water treatment methods should be suitable for this purpose. The ability to reject small organic contaminants makes nanofiltration membranes almost a nature choice for emerging contaminants. Compared with

Table 1. Main group of emerging contaminants, definitions and examples

Group	Definition	Examples	Environmental Risks	Comments
Pesticides	Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest (by US EPA)	Atrazine, Diuron, Alachlor, Diazinon	Probable human carcinogen, endocrine disrupting potential	Dominant group in the list of persistent organic pollutants (Berg, Hagmeyer, & Gimbel, 1997)
Disinfection by-products (DBPs)	The byproducts formed by the reaction between disinfectants and naturally-occurring materials	Trihalomethanes, Haloacetic acids	Increased risk of cancer and liver, kidney, or central nervous system problems	
Endocrine disrupting chemicals (EDCs)	The chemicals which can interfere with body's endocrine system	Estrone, Estriol, Testosterone, Progesterone	Developmental, reproductive, neurological, and immune effects in both humans and wildlife	Certain fish and wildlife are easy to be affected.
Pharmaceutically Active Compounds (PhACs)	Pharmaceutical residues and their metabolites	Ibuprofen, Diclofenac, Diatrizoateb	Inherent potential for a wide range of physiological effects	Potential for induction of proliferation of antibiotic resistance (Van Wyk, 2015)