

The Occurrence and Fate of Pharmaceuticals, Personal Care Products and Endocrine Disrupting Compounds in a Municipal Water Use Cycle:

A Case Study in the Cities of Ann Arbor, Grand Rapids, and Monroe

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Abstract

In 2005 a characterization of the occurrence and fate of a 22 compound target list of pharmaceuticals, personal care products and endocrine disrupting compounds (PPCPs and EDCs) was performed at various locations within the City of Ann Arbor's (Ann Arbor), City of Grand Rapids (Grand Rapids), and City of Monroe (Monroe) water use cycle. Monitoring occurred at four locations within the Ann Arbor and Grand Rapids water use cycle:

- Surface/source water
- Drinking water
- Wastewater influent
- Wastewater effluent

Monitoring occurred at two locations within the Monroe water use cycle:

- Surface/source water
- Drinking water

Laboratory analysis indicated the following number of target compounds identified in grab samples collected from Ann Arbor, Grand Rapids, and Monroe monitoring stations over the four sampling events:

- 18 of 22 compounds detected in source water
- 10 of 22 compounds detected in finished drinking water
- 21 of 22 compounds detected in wastewater influent
- 20 of 22 compounds detected in treated wastewater effluent

Results of this study indicate a reduction in the concentrations of certain compounds based on samples collected before and after source water and wastewater treatment processes. Data indicates some variability in the removal of PPCPs and EDCs in water and wastewater systems depending on the treatment process. Additionally, characterization of occurrence and concentration of analytes in source water supplies is similar in the three Michigan communities.

INTRODUCTION

Research reviewed over the course of this study indicates there has been an increasing interest over the last several years in characterizing the occurrence and fate of endocrine disrupting compounds (EDCs), pharmaceuticals and personal care products (PPCPs) in water use cycles in the United States and Europe. PPCPs are often described as a grouping of chemical substances that range from prescription drugs to fragrances and cosmetics. The American Water Works Association (AWWA) defines EDCs as chemicals that interfere with the normal function of the endocrine system. The endocrine system includes endocrine glands and the hormones produced from these glands. Examples of these glands include the pituitary, thyroid, and pancreas. The group of EDCs contains a wide range of compounds such as steroids, pesticides, inorganics, and industrial chemicals.

Currently, other researchers are evaluating the environmental effects of human and aquatic exposure to PPCPs and EDCs. Additionally, studies completed over the past few decades have recognized that the potential exists for PPCPs to enter the environment from multiple routes, such as, wastewater treatment discharge, industrial discharge, runoff from confined animal feeding operations, and treated sludge applied to agricultural land. (Daughton and Ternes, 1999). PPCPs may enter the treatment process in a reduced form (after passing through body) or by direct discharge of discarded PPCPs.

Points of PPCP and EDC entry into the environment include:

1. Discharge from Wastewater treatment processes such as treatment plant or septic systems,
2. Regulated and unregulated industrial discharges to surface and groundwater,
3. Leaking or overflowing animal waste storage from confined animal feeding operations,
4. Land application of treated animal waste from certain animal feeding operations.

Studies on this topic include the 1999-2000 United States Geological Survey (USGS) National Reconnaissance. The USGS National Reconnaissance was a comprehensive study that characterized the occurrence of PPCPs and EDCs in various surface water resources nationwide. The study reported that water samples collected from 80% of 139 streams monitored in 30 states found one or more of the study's 95 target analytical compounds (including pharmaceuticals, hormones, and other wastewater compounds). The sampling sites were selected in areas prone to contamination from agricultural, industrial and metropolitan wastewater (Koplin, 2002).

The purpose of the study reported herein was to evaluate the occurrence and fate of certain PPCPs and EDCs at key locations within the each of the City's water use cycle. City staff performed sampling at all locations. Baylor University Laboratories was chosen to perform lab analysis based on their past and on going work in this area. Specifically, data was obtained by performing laboratory analysis of manually collected water samples for a target compound list of pharmaceuticals, personal care products, and endocrine disruptors. The data were used to characterize the occurrence, fate, and transport of the compounds in the water cycle in three communities in Michigan during four discreet sampling events. This report documents the field and laboratory methods used to complete the analysis of the target compound list. Additionally, this report describes the water use cycle and summarizes the results of the analytical laboratory reports.

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Figure 1. Huron River upstream of the Ann Arbor's water intake



Figure 2. Lake Michigan, source of water for Grand Rapids



Figure 3. Lake Erie, source of water for Monroe

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The target compound list developed for this study was primarily based on three criteria:

1. Compounds identified in the 2003 Case Study in Ann Arbor,
2. Ability to complete analysis using defined laboratory methods, and
3. Frequency of compound occurrence in surface and wastewater in the United States and Europe as reported in reviewed literature.

The target compounds for this study are listed in Table 1.

Table 1. Target Compound List

PPCPS & EDCs	Use/Origin	Analytical Method
<i>Antibiotics</i>		
Sulfamethoxazole	human antibiotic	LC/MS/MS
Lincomycin	human/veterinary antibiotic	LC/MS/MS
Tylosin	veterinary antibiotic	LC/MS/MS
Trimethoprim	human antibiotic	LC/MS/MS
<i>Analgesics</i>		
Acetaminophen	pain reliever	LC/MS/MS
Codeine	pain reliever	LC/MS/MS
Ibuprofen	pain reliever	LC/MS/MS
<i>Antidepressants</i>		
Fluoxetine	antidepressant	LC/MS/MS
Norfluoxetine	antidepressant	LC/MS/MS
<i>Antiepileptic</i>		
Carbamazepine	antiepileptic/antimanic	LC/MS/MS
<i>b-adrenergic Blockers</i>		
Atenolol	b-adrenergic Blockers	LC/MS/MS
Metoprolol	b-adrenergic Blockers	LC/MS/MS
Propranolol	b-adrenergic Blockers	LC/MS/MS
<i>Hormones and Sterols</i>		
17b-estradiol	hormone	GC/MS
17a-ethinylestradiol	steroidal hormone	GC/MS
Estrone	steroidal hormone	GC/MS
Estriol	steroidal hormone	GC/MS
Cholesterol	plant steroid	GC/MS
Coprostanol	fecal steroid	GC/MS
<i>Lipid Regulator</i>		
Clofibrilic Acid	lipid regulator	LC/MS/MS
Gemfibrozil	lipid regulator	LC/MS/MS
<i>Stimulant</i>		
Caffeine	stimulant	GC/MS

