Emerging Contaminants: Removal Efficiency of Micronic Technologies' MicroEVAP™ Water Purification System

Emerging contaminants (EC) are those chemical and microbial constituents that historically have not been monitored, regulated, or considered as contaminants but have been, in contemporary times, determined to be at risk of being pervasive to such a degree in the environment that they may have adverse ecological effects or cause health issues for persons exposed (1). A class of EC that has received increased attention recently includes pharmaceuticals and personal care products (PPCPs) which, due to improved analytical detection sensitivity (2,3) and their global prevalence (4-6), are being identified in surface waters and the possible impact has become an issue of concern (7). The route for entry of many of these contaminants to the surface water supply is clearly the effluent resulting from domestic wastewater treatment processes. As of 2008, more than three quarters of the United State's population was served by a centralized (non septic or other) wastewater treatment plant (WWTP) (8). Such treatment plants are incapable of efficient removal of ECs as shown by study of their effluent. Nearly 70 percent of the U.S. population is served with community water systems that draw on surface water (9), leading to the likelihood that these contaminants are cycling back into the drinking water of such communities (10). Thus, the study described herein chose as subjects the effluents from three wastewater treatment plants (WWTPs), one small community plant (WWTP1, population <3,000) and two urban WWTPs (WWTP2 and WWTP3, populations of 22,000 and 44,000 respectively) to determine the presence of selected PPCPs (Table 1) in the WWTP secondary effluents and the effectiveness of a novel evaporative water treatment technology, MicroEVAP™, in the removal of the identified PPCPs from the effluents.

Table 1 Pharmacuetical and Personal Care Products (PPCPs) selected for screening

Amitriptyline	Erythromycin	Ornidazole
Atrazine	Escitalopram	Oxolinic Acid
Buprenorphine	Flumequine	Primidone
Carbamazepine	Gabapentin	Propranolol
Cefotaxime	Lidocaine	Sertraline
Chlorotetracycline	Lorazepam	Sulfamethazine
Clenbuterol	MDMA	Tetracycline
Cocaine	Mefenamic Acid	Thiabendazole
Cotinine	Meprobamate	Triamterene
DEET	Metformin	Trimethoprim
Dextromethorphan	Nalidixic Acid	Tylosin
Diltiazem	Nifedipine	Vancomycin
EDDP	Ormetoprim	Venlafaxine

Approximately 10 liters of secondary effluent was collected from each WWTP and transported to Micronic Technologies, in Wise, VA, where it was processed through the 2nd prototype of the MicroEVAP™ purification system

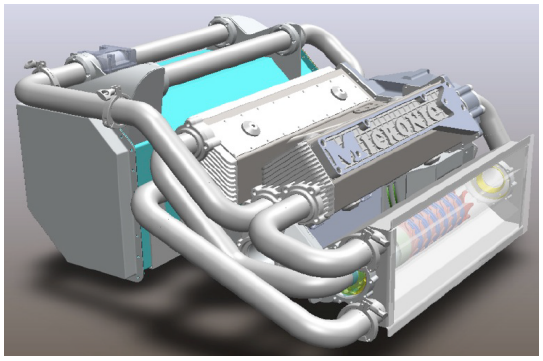

Figure 1 MicroEVAP™ Prototype 2.0

(Figure 1) following a thorough rinse and blank run of distilled water before starting the next run to avoid cross contamination between samples. Samples of the three MicroEVAP™ processing streams (pre-treated water, waste, and product) were collected in triplicate for each WWTP secondary effluent and were frozen for transportation and storage until analysis.

Each sample was extracted and cleaned up by passing through an Oasis HLB cartridge (60 mg, 3cc, Waters Co., Milford, MA) at 5 mL/min, eluted with methanol, dried down, reconstituted, and screened for 39 PPCPs on an ultra performance liquid chromatography tandem mass spectrometry (UPLC/MS/MS). Spiked water samples and blank water, as quality check, were processed and screened as well. The peak areas of each identified compound in the pre- and post- treated water samples were compared to calculate the EC removal efficiency of MicroEVAP™.

Table 2 Test Results for Processed Samples through MicroEVAP™

Emerging Contaminants	Usage	Detected in the pre-treated water			ECs removal efficiency (%)
		WWTP1	WWTP2	WWTP3	
Amitriptyline	depression and anxiety medication		√	√	100
Atrazine	pesticide		√	√	100
Buprenorphine	opiod medication	√	√		100
Carbamazepine	anticonvulsant	√	√	√	100
Cocaine	recreational drug		√	√	100
Cotinine	predominant metabolite of nicotine	√	√	√	100
Dextromethorphan	cough suppressant	√	√	√	99-100
Diltiazem	high blood pressure medication	√	√	√	100
EDDP	metabolite of Methadone	√	√	√	100
Erythromycin	antibiotic		√	√	100
Escitalopram	depression and anxiety medication	√	√	√	100
Gabapentin	anticonvulsant	√	√	√	100
Lidocaine	numbing agent	√	√	√	100
Lorazepam	medication for anxiety disorders	√		√	100
Meprobamate	anxiolytic medication	√	√	√	100
Metformin	oral diabetes medicine	√	√	√	100
Nalidixic Acid	synthetic quinolone antibiotic		√	√	100
Primidone	anticonvulsant		√	√	100
Propanolol	angina and hypertension medication	√	√	√	100
Sertraline	antidepressant	√	√	√	98-100
Tetracycline	antibiotic	√	√		100
Thiabendazole	antibiotic	√	√	√	100
Triamterene	hypertension and edema medication	√	√	√	100
Trimethoprim	antibiotic	√	√	√	100
Vancomycin	antibiotic	√	√	√	100
Venlafaxine	medication for depression, anxiety, and panic		√		100

Of the 39 ECs selected for screening, a total of 26 different PPCPs were found in at least one sample: 19 were present in the effluent of WWTP1, 25 in WWTP2's effluent and 23 in that of WWTP3. Using the chromatograms of one compound as example, Figure 2 clearly illustrates the presence of this compound in both pre-treated WWTP effluent and processed waste and its absence in the blank water and processed product water. Similar observations were made for all other screened compounds for all three WWTP effluent samples tested. By comparing the

chromatographic peak areas of each compound for the pre-treated WWTP effluent and effluent product water (Figure 2a), the removal efficiency of the MicroEVAP™ water purification system was determined to be 98-100% for all detected PPCPs (Table 2). Comparison of the chromatographic peak areas of each compound for the pre-treated WWTP effluent and the waste (Figure 2b) showed that PPCPs were concentrated (not changed chemically) in the waste of the treatment process (~15% of the pre-treated WWTP effluent by mass).

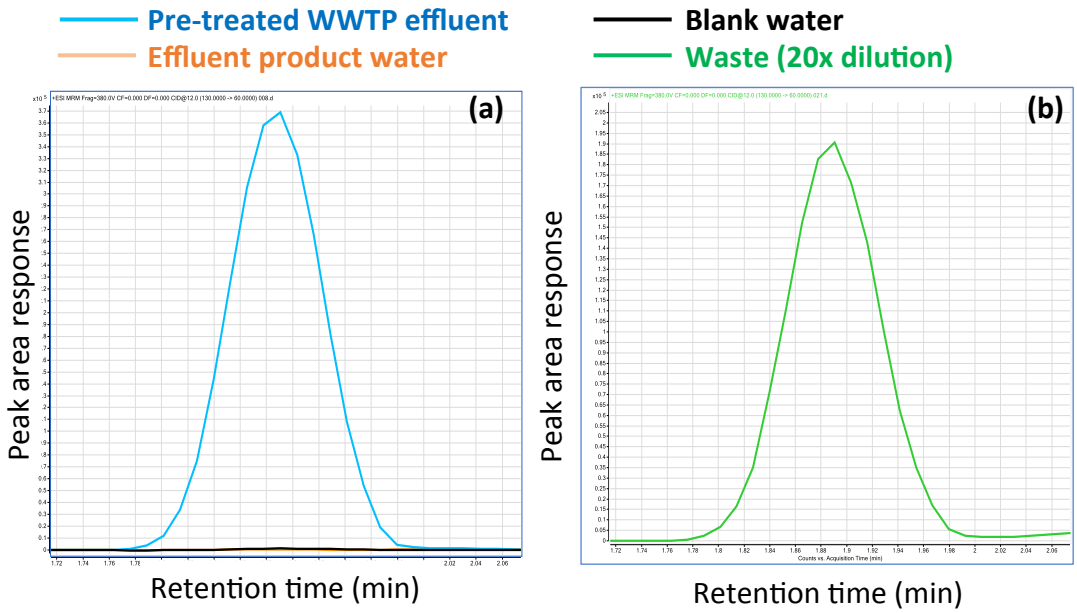

Figure 2 Example of a chromatogram set (metformin) used in peak analysis (a) Overlaid chromatograms of pre-treated effluent, effluent product, and blank (b) Chromatogram of 20x diluted waste

The positive results of the near complete removal of all detected PPCPs from the pre-treated WWTP effluent to the product water indicate that the MicroEVAP™ mechanical evaporative purification process is capable of reducing the impact of many emerging contaminants currently left untreated in the wastewater treatment process. Future research to follow includes quantification of ECs in a wider network of wastewater treatment plants, the efficiency of the novel purification process over a range of concentrations for more specific groupings within the list of ECs, and a possible solution for disposal or resource recovery of the compounds that are concentrated in the waste.

Reference List

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