# Advanced Treatment To Remove Microconstituents



Studies indicate several technologies show potential to remove endocrine disrupting compounds and pharmaceutical and personal care products

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icroconstituents, which include such chemicals as endocrine-disrupting compounds (EDCs) and pharmaceutical and personal-care products (PPCPs), have earned considerable attention from the public and regulators in recent years. Most of these concerns stem from their known aquatic and environmental impacts and potential human health effects at very low (part-per-trillion or part-per-quadrillion) concentrations. Unfortunately, traces of EDCs and PPCPs are not easily removed by conventional wastewater treatment processes.



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The City of Phoenix has conducted two studies to examine technologies for the removal of pathogens, EDCs, and PPCPs. The first phase, which at press time was due to be completed

this spring, included a pilot study to evaluate various combinations of disinfection processes at the city's 91st Avenue Wastewater Treatment Facility. The pilot test included evaluation of the germicidal effectiveness of these disinfection technologies while also removing various types of microconstituents. The second study compared the removal of microconstituents at four wastewater treatment plants,

including the 91st Avenue plant. Results from these studies indicate that various technologies can achieve pathogen and microconstituent removal.

# **How Microconstituents Are Removed**

With a seemingly endless number of uses and origins in residential, industrial, and agricultural applications, microconstituents are ubiquitous

in the environment. Many of these compounds have been shown to change the function of the endocrine system, affecting the way an organism reproduces, grows, or develops. Although the potential hazards of some of these chemicals have been known for decades, the environmental effects of microconstituents are more recently gaining worldwide attention.

Evidence linking microconstituents with negative

of several studies. For example, natural and

The 91st Avenue Wastewater Treatment Facility in **Phoenix serves** more than 2 million people.

wildlife health effects is mounting. The potential environmental and health effects of microconstituents on ecosystems near wastewater treatment plant discharges have been the focal point

600000 500000 Fecal Coliforms (cfu/100 mL) 400000 300000 200000 100000 30 50 100 200 UV dose, mJ/cm2

Figure 1. Fecal Coliform Results Using UV and 5 mg/L Peracetic Acid

synthetic estrogens in treatment plant discharge have been implicated in endocrine disruption and feminization in fish.

Microconstituents potentially may be removed through adsorption, biological degradation and transformation, chemical degradation, or volatilization, depending on their physicochemical properties. However, little has been reported on their fate through wastewater treatment processes. Most of the findings reported in the literature indicate that removal efficiency depends on the type of compound and the removal process. In addition, conventional treatment processes likely will be inadequate to remove high amounts of a sufficient number of compounds.

Several technologies that appear to have good potential for microconstituent removal are activated carbon adsorption, reverse osmosis and tight nanofiltration systems, ozone, and advanced oxidation processes, such as ultraviolet (UV) plus hydrogen peroxide, ozone plus hydrogen peroxide, and UV plus ozone. It should be noted that most of these technologies remove microorganisms as well as microconstituents.

### **Phoenix Disinfection Options**

The 91st Avenue Wastewater Treatment Facility serves more than 2 million people living in Phoenix, Scottsdale, Tempe, Glendale, and Mesa, Ariz. The 680,000-m<sup>3</sup>/d (180-mgd) plant

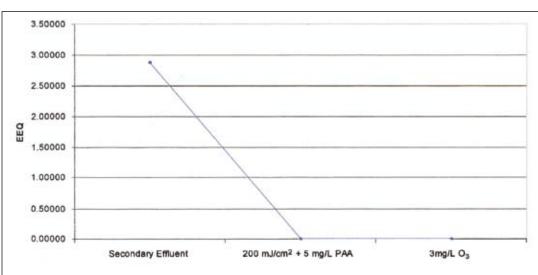


Figure 2. Estrogenic Assay Results From Onsite Testing

PAA = peracetic acid.

EEQ = estradiol equivalent.



comprises six individual trains. Chlorine gas is used to disinfect the plant effluent before discharge.

A master plan that was developed to expand the treatment plant to 2.3 million m<sup>3</sup>/d (600 mgd) recommended the conversion to UV disinfection. Two separate but related studies were launched: The first study consisted of an onsite bench-scale evaluation of a variety of filtration and disinfection methods to identify which combination would remove both microconstituents and pathogens; the second study, conducted by researchers at Duke University (Durham,

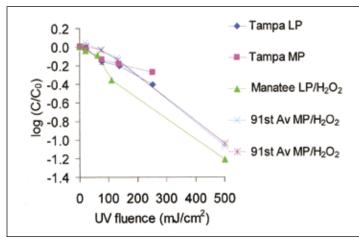
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N.C.), examined the use of various technologies to remove specific microconstituents.

### **Onsite Bench Testing**

Disinfection processes and combinations that were subjected to pilot testing include UV light, ozone, UV plus ozone, UV plus hydrogen peroxide, UV plus peracetic acid, and ozone plus hydrogen peroxide, with the goal of meeting Arizona's A+ disinfection requirements (4 of 7 nondetects for fecal coliforms). Using UV alone at one of the city's water reclamation facilities proved to be challenging from both compliance and

Figure 3. Duke University N-Nitrosodimethylamine Testing



LP = low-pressure UV. MP = medium-pressure UV.

operating standpoints.

During Phase 1 of the study, samples were collected and analyzed onsite. One of the study goals was to determine if A+ requirements could be achieved without filtration. Initial studies indicated that filtration would be required; therefore, all samples tested for microconstituents were filtered before being exposed to the disinfection and advanced oxidation process. While more than 50 different bench-scale tests were conducted to examine high-level disinfection, only 10 of these tests were actually completed in the advanced oxidation mode. Results from the study showed nondetect bacteria results could be achieved with a dose as low as 10 mJ/cm<sup>2</sup> when combined with 6 mg/L peracetic acid (see Figure 1, p. 48). At this low dose, however, the desired microconstituent removal would not be achieved. Therefore, the UV dose was increased to 200 mJ/cm<sup>2</sup>.

To examine microconstituent removal, an estrogenic bioassay approach was used. Assays were conducted on secondary effluent: a filtered sample was treated with 200 mJ/cm<sup>2</sup> in the presence of 5 mg/L peracetic acid, and another filtered sample was treated with 3 mg/L ozone. The results of this study yielded similar results regardless of the disinfection methodology (see Figure 2, p. 48). Testing was conducted to assess the removal of the human carcinogen N-Nitrosodimethylamine (NDMA) using UV plus peracetic acid, ozone, and UV alone. Results indicated that a UV dose of 140 mJ/cm<sup>2</sup> alone could remove approximately 44% of NDMA in effluent, while an ozone dose of 3 mg/L would remove approximately 67%.

## **Duke University Study**

The Duke University study included samples from the 91st Avenue plant, as well as samples from Tampa, Bradenton, and Manatee water reclamation facilities in Florida. The 91st Avenue plant was the only one that did not have effluent filtration. Wastewater samples were collected and shipped to Duke University for testing. This study focused on the removal of various microconstituents. Bench-scale testing was completed using 5 mg/L peroxide (from stock that was 25% by weight) and varying the UV dose to measure the removal of the various spiked microconstituents.

The results for ethinyl estradiol, a form of estrogen used in oral contraceptives, at the 91st Avenue plant were lower than those for the Bradenton facility but similar to those for the Tampa facility. The difference in removals may be attributed to the effluent quality produced at each plant. For metolachlor, a slightly toxic compound used in herbicides, the 91st Avenue facility reported the best removal.

Samples from each wastewater treatment plant were spiked with a known dose of NDMA and then exposed to UV plus hydrogen peroxide. The results for NDMA removal for both the Manatee and the 91st Avenue treatment plants showed that same level of removal can be achieved in both plants (see Figure 3, above).

### **Promising Results**

Although the final report for the first study is still under development, findings of the tests conducted at the 91st Avenue treatment plant are promising for the treatment of wastewater effluent. UV transmittance testing results appear to be within the typical range for secondary treated effluent. UV collimated-beam disinfection testing results indicate that the disinfection requirements established by the Arizona Department of Environmental Quality can be met. Results of initial ozone testing show that this method of disinfection can be viable for this facility.

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