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Sources of endocrine-disrupting chemicals in urban wastewater, Oakland, CA

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ABSTRACT

Synthetic endocrine-disrupting chemicals (EDCs) have been found in surface waters throughout the United States, and are known to enter waterways via discharge from wastewater treatment plants (WWTPs). Studies addressing EDCs in wastewater do not examine their specific sources upstream of WWTPs. Presented here are results of a pilot study of potential sources of selected EDCs within an urban wastewater service area. Twenty-one wastewater samples were collected from a range of sites, including 16 residential, commercial, or industrial samples, and five samples from influent and effluent streams at the WWTP. Samples were analyzed for the following known and suspected EDCs: five phthalates, bisphenol A (BPA), triclosan, 4-nonylphenol (NP), and tris(2-chloroethyl) phosphate (TCEP), using well-established methods (EPA 625 and USGS O-1433-01). Twenty of 21 samples contained at least one EDC. Phthalates were widely detected; one or more phthalate compound was identified in 19 of 21 samples. Measurement of two phthalates in a field blank sample suggests that the accuracy of sample detections for these two compounds may be compromised by background contamination. Triclosan was detected in nine samples, BPA in five samples, and TCEP in four samples; NP was not detected. The results of this and future source-specific studies may be used to develop targeted pollution prevention strategies to reduce levels of EDCs in wastewater.

1. Introduction

Endocrine-disrupting chemicals can interfere with natural hormone cycles in humans or animals, potentially affecting metabolism, development, reproduction, and growth. Fish and wildlife can be exposed to exogenous, anthropogenic EDCs through contaminated surface waters (Kolpin et al., 2002; Pait and Nelson, 2002). Concentrations of some EDCs in surface waters are detected in the parts per trillion or parts per billion range, but evidence is mounting that, even at these low levels, EDCs may adversely impact wildlife, especially water-dwelling animals (Pait and Nelson, 2002; Wozniak et al., 2005; Veldhoen et al., 2006). Impacts of EDCs on wildlife have been documented in animals at all levels of the food chain, from polar bears, whales, fish, and predatory sea birds (Jenssen, 2006; Kavanagh et al., 2004), to *Ceriodaphnia*, the water flea (Henry et al., 2004).

Numerous studies identify WWTPs as sources of EDCs in surface water bodies (Barnes et al., 2002; Harrison et al., 2006; Pryor et al., 2002), but do not test upstream of WWTPs to identify sources of EDCs. Measuring EDC levels from individual sources could increase understanding of the full range and magnitude of EDCs in WWTP influent, as well as provide insights into potential pollution prevention strategies to reduce the levels of EDCs in WWTP effluent. The East Bay Municipal Utility District (EBMUD) and the non-profit Environmental Working Group (EWG) collaborated on a joint study of sources of EDCs to the EBMUD WWTP, located in Oakland,

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CA (Fig. 1). Sixteen wastewater samples were collected from residential, commercial, or industrial locations upstream of the WWTP. Two pre-treatment influent and three post-treatment effluent samples were also collected. Wastewater samples were examined for five phthalates, bisphenol A (BPA), triclosan, 4-nonylphenol (NP), and tris(2-chloroethyl) phosphate (TCEP), all persistent, synthetic chemicals found to disrupt hormone systems in laboratory studies (Table 1). Results from this preliminary examination can inform the design of future studies that probe upstream sources of EDCs.

2. Methods

2.1. Wastewater sample collection

Wastewater samples were collected within the East Bay Municipal Utility District's (EBMUD) wastewater service area, on the eastern shore of San Francisco Bay (Fig. 1). A total of 16 samples were drawn from the following locations: a residential area (two samples); a variety of commercial locations, including a nail salon, two industrial laundry facilities, a residential coin laundry, a diaper service, a pet wash, a veterinary clinic, a hospital, and an outpatient medical clinic; and several industrial locations, including facilities manufacturing pharmaceuticals, plastic bags, paper products, beverages, and adhesives. Samples were drawn from sanitary sewer cleanouts, sewer lines, and other access points to waste streams prior to their commingling with wastewater from other sources.

In addition, five samples of wastewater were collected from waste streams entering (two samples) and exiting (three samples) the EBMUD wastewater treatment plant before discharge into the Bay. The EBMUD WWTP treats approximately 75 million gallons of wastewater per day from roughly 640,000 residents, as well as commercial businesses and industries. Pre-treatment influent sampling was intended to provide snapshots of the total loading of selected EDCs for the region, and treated wastewater effluent sampling was intended to provide a post-treatment indication of which EDCs may reach San Francisco Bay at detectable concentrations. Comparison of pre- and post-treatment samples does not provide an indication of the effectiveness of treatment in removal of EDCs from the wastewater stream, because the samples collected represent water characteristics over a discrete time period only, and do not capture variation in the levels of EDCs in wastewater that may occur diurnally, seasonally, or annually. Removal rates by wastewater treatment can be found in other comprehensive studies (e.g. Oppenheimer et al., 2007; Snyder et al., 2007).

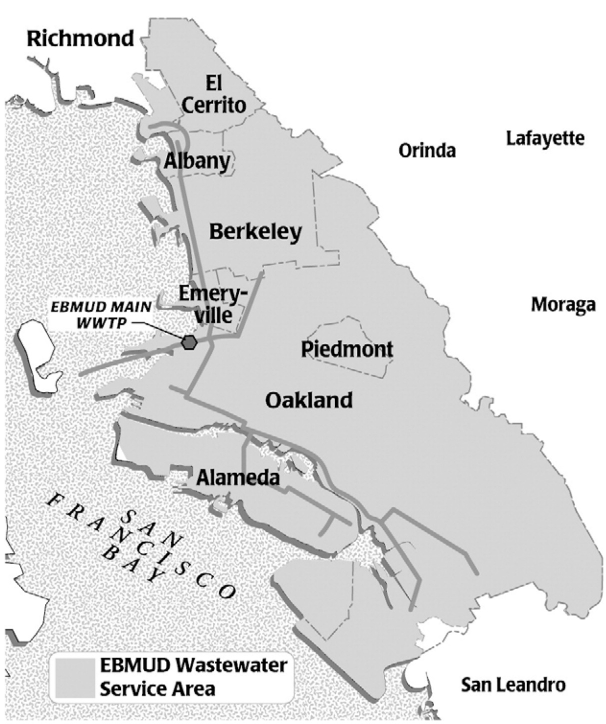

Fig. 1 – The East Bay Municipal Utility District wastewater service area.

Wastewater samples were collected on three days, August 16, September 6, and November 28, 2006. Sampling occurred on dry days, at least 48 h after a rain event, to reduce the effect of dilution by stormwater infiltration into the wastewater collection system.

At each sampling location, EBMUD field staff collected two 1-liter samples of wastewater. Because each site had different access and safety requirements, to maintain consistency across sampling sites all samples were grab samples, taken within a 15-minute period. Samples were collected in amber glass bottles pre-cleaned using Alconox®, an anionic cleanser that passes residue tests for water analysis. The amber glass containers were completely filled to reduce air contamination and/or volatilization. EBMUD staff also collected two "field blank" samples of de-ionized, carbon-filtered water for analysis of potential contamination from sampling protocol and equipment, one on each of the first two days of sample collection.

Because EDCs may be found in housekeeping and personal care products, prior to sample collection EBMUD field staff avoided contact with soaps and detergents, cleansers, pesticides, fragrances, and sunscreen.

2.2. Laboratory analysis

All samples were placed in a 4 °C refrigerator for preservation until analysis could be completed. Half of the samples collected on August 16 and September 6 were chilled overnight, then packaged in a cooler and sent via overnight delivery to Montgomery Watson Harza (MWH) Laboratories in Monrovia, CA.

Two standardized gas chromatography/mass spectrometry (GCMS) methods for chemical analysis were used, EPA 625 (phthalates; EPA, 2007) and USGS O-1433-01 (BPA, TCEP, triclosan, NP; USGS, 2007), each of which requires a 1-liter sample. East Bay Municipal Utility District laboratory staff analyzed all samples with EPA Method 625 for semi-volatile organic compounds. Samples collected August 16 and September 6 were subjected to USGS Method O-1433-01, a screen for EDCs, by MWH Laboratories, and those collected November 28 were subjected to the same analysis by EBMUD.

These analytical methods were designed to detect trace amounts of contamination in natural waters, as opposed to the