

Toxicological Relevance of EDCs and Pharmaceuticals in Drinking Water [Project #3085]

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PRINCIPAL INVESTIGATORS:

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OBJECTIVES:

The primary objective of this project was to establish a suite of indicator pharmaceuticals and potential endocrine disrupting compounds (EDCs) to be used for evaluating the exposure and health implications from drinking water. A secondary objective was the development of robust analytical methods to identify and quantify the indicator compounds in raw and finished drinking water. The final objective was the evaluation of toxicity data with occurrence data in order to develop a human health risk assessment for indicator pharmaceuticals and potential EDCs in U.S. drinking waters.

BACKGROUND:

Analytical technology has made it possible to detect and quantify nearly any compound known to humankind at diminishingly minute concentrations in water. Although the earliest reports of pharmaceuticals and steroid hormones in water date back nearly four decades, it is only within the past decade that the subject has come to the forefront of scientific and public attention. Today we know definitively that trace levels of pharmaceuticals, potential EDCs, and other emerging contaminants do occur in source water, and to a lesser extent, in finished drinking water. Based on research thus far, it appears that many conventional and advanced treatment processes will greatly reduce the concentrations of these compounds. Nevertheless, considering the continued advancements in analytical technologies, today's non-detectable contaminants will be tomorrow's emerging contaminants. If presence/absence becomes our litmus test for risk and subsequent actions, treatment technology will be increasingly, and perhaps unnecessarily, costly and energy intensive. This is an especially important consideration due to the energy cost and greenhouse gas emissions of advanced treatment. For these reasons, it is of utmost importance to determine human health-based screening levels from which meaningful treatment goals and analytical detection limits can be established.

HIGHLIGHTS:

Of the 62 target compounds investigated, only 3 were consistently (>50 percent frequency) detected in U.S. drinking water despite parts per trillion reporting limits. The compounds with the highest frequency of occurrence were atrazine (83 percent), meprobamate (78 percent), and phenytoin (56 percent). Of 18 target pharmaceuticals, 9 were detected at least once in drinking water; none occurred at concentrations above the calculated acceptable daily intake (ADI). Only 4 of the 13 target potential EDCs were detected in at least one drinking water, and none occurred at concentrations above their corresponding ADIs.

In summary, while some target pharmaceuticals and potential EDCs were measurable in trace quantities, none occurred at levels predicted to be of relevance to human health.

APPROACH:

A suite of 62 indicator pharmaceuticals and potential EDCs were selected based upon literature reviews of

potential for toxicity, propensity for occurrence, and analytical capability. Robust analytical methods utilizing isotope-dilution and tandem mass spectrometry were developed in order to monitor the raw and finished waters of 20 U.S. drinking water facilities with ng/L sensitivity. An *in vitro* bioassay was used to screen for estrogenicity in the same waters. A series of bottled waters and food and beverage items were also screened for estrogenicity for a benchmark comparison. Risk evaluations for exposure through drinking water were conducted for 16 pharmaceuticals, 10 potential EDCs, and 3 steroid hormones. ADIs were calculated using methods consistent with USEPA approaches for determining levels of exposure to environmental contaminants.

RESULTS/FINDINGS:

Of the 62 target compounds investigated, only 11 were detected in U.S. drinking water at >20 percent frequency. Of these 11 compounds, only 9 would have been detected using an analytical method reporting limit (MRL) of 10 nanograms per liter (ng/L, or parts per trillion) and only 3 would have been detected using an MRL of 100 ng/L. The maximum-detected concentrations in drinking water were used to calculate drinking water equivalent levels (DWELs). Using this approach, none of the pharmaceuticals detected in drinking water exceeded their corresponding DWEL. Minimum margins of safety, defined as the DWEL divided by the maximum-detected finished or distribution water concentration, were 6,000 for meprobamate, 6,000,000 for sulfamethoxazole, and 2,200,000 for triclosan. The estimated potential hazard associated with exposure to the beta-blocker atenolol was also relatively low, with a DWEL of 70 µg/L and a minimum margin of safety 2,700. The margins of safety of three other detected compounds, diazepam (110,000), fluoxetine (41,000), and norfluoxetine (44,000), were also very large. Similarly, none of the potential EDCs examined exceeded the calculated health risk threshold. Atrazine, with the maximum detected concentration in finished drinking, yielded a minimum margin of safety of three. Minimum margins of safety for bisphenol A and p-nonylphenol were 72,000 and 16,000, respectively. Thus, based upon the health risk evaluation, none of the indicator pharmaceuticals and potential EDCs are of human health relevance based on levels of occurrence in the U.S. drinking waters evaluated.

IMPACT:

This report provides water utilities with a representative survey of pharmaceutical and potential EDC occurrence in U.S. drinking waters. The report provides guidance to gauge the health relevance of a selected group of pharmaceuticals and potential EDCs. The calculated health-based values can be used to guide the establishment of meaningful method reporting limits and water treatment goals. Moreover, this report provides critical talking points that will aid utilities in communicating scientific data regarding pharmaceuticals and potential EDCs with customers.

MULTIMEDIA:

The appendices are included on a CD-ROM.

RESEARCH PARTNERS:

- WateReuse Foundation
- Southern Nevada Water Authority

PARTICIPANTS:

A broad network of water experts in various locations across the United States collaborated on this project.

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