Fate of Estrogenic Compounds During Municipal Sludge Stabilization and Dewatering

Researchers have identified key baseline information concerning the estrogenicity and concentrations of individual trace organic compounds during common wastewater treatment processes. This project is one of the first research efforts to look specifically at the fate of these compounds throughout the solids phase of treatment. The results shed new light on the occurrence, concentration, characteristics, and potency of estrogenic compounds that preferentially partition onto solids during common wastewater treatment processes.

The Environmental Protection Agency (EPA) recently published the results of its Targeted National Sewage Sludge Survey. EPA sampled 145 trace organic compounds from 74 municipal wastewater treatment plants. Some compounds were found in concentrations as high as hundreds of parts per million. "Trace organics" is a term that encompasses a number of different types of household and industrial compounds, including pharmaceuticals, personal care products, flame retardants, plasticizers, detergents, and pesticides. Some of these compounds have been shown to disrupt the reproductive systems of aquatic organisms.

Full-Scale Testing Was Conducted by a Team of Experts at Four Treatment Plants

WERF assembled a team of experts in the fields of environmental engineering, chemistry, and hydrogeology to evaluate the occurrence and fate of estrogenic compounds in typical solids treatment processes. The research was led by AECOM, the U.S. Geological Survey, and the University of Arizona.

The researchers collected samples at four full-scale wastewater treatment plants over two years. The biosolids stabilization processes included in the study were aerobic digestion, anaerobic digestion (both mesophilic and thermophilic), and lime stabilization. A suite

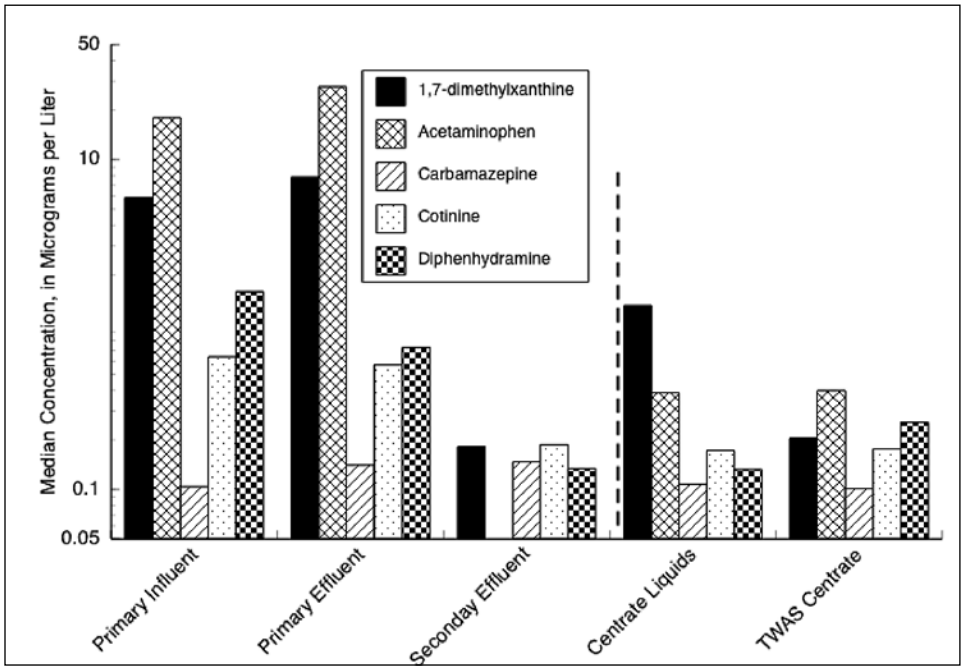

Figure 1. Median Concentrations of Select Pharmaceuticals from Unit Process Samples Common to Plants A-D.

BENEFITS

- Demonstrates the total estrogenicity leaving the plant in the treated effluent and biosolids is less than the total estrogenicity entering the plant in the primary effluent.
- Offers insights into the primary sources of estrogenic activity in biosolids through comparison of estrogen analyses and measures of whole-sample estrogenic activity.

RELATED PRODUCTS

Contributions of Household Chemicals to Sewage and Their Relevance to Municipal Wastewater Systems and the Environment (03CTS21UR)

Fate of Pharmaceuticals and Personal Care Products through Municipal Wastewater Treatment Processes (03CTS22UR)

Technical Brief: Endocrine Disrupting Compounds and Implications for Wastewater Treatment (04WEM6)

State-of-the-Science Review of Occurrence and Physical, Chemical and Biological Processes Affecting Biosolids-Borne Trace Organic Chemical in Soils (SRSK5T09)

Disinfecting and Stabilizing Biosolids Using E-Beam and Chemical Oxidants (U4R06)

Trace Organics Compounds and Implications for Wastewater Treatment (CEC3R07)

Evaluation of QSPR Techniques for Wastewater Treatment Processes (U2R07)

RELATED ONGOING RESEARCH

Categorizing Wastewater Treatment Processes by their Efficacy in Reduction of a Suite of Indicator TOrC (CEC4R08)

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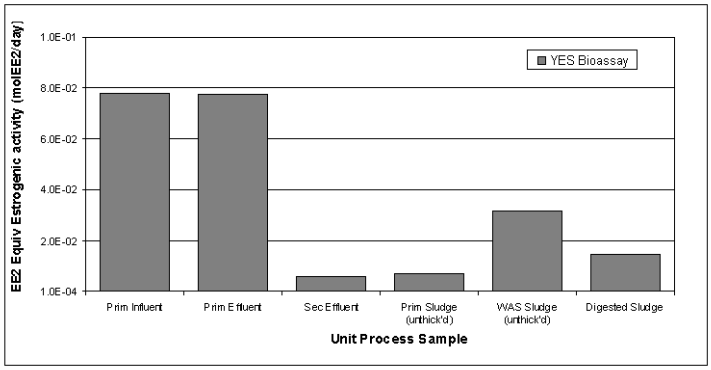

Figure 2. Daily Mass Flux of Estrogenic Activity at Plant D.
(Based on YES Bioassay Measurements – June 2006 Data Only)

of about 100 trace organic compounds, including sterioidal hormones, pharmaceuticals, and anthropogenic wastewater indicators, was analyzed. For each sample, chemical analysis and bioassay measurements were made to quantify estrogenic compounds and estrogenic activity. (Bioassays use test organisms to evaluate the effects of substances being studied.)

The researchers calculated the amounts of trace organics and estrogenic activity for each sample point. This enabled the team to better understand the relevance of trace organic concentrations and estrogenic activity of solids as they moved through the study plants.

WERF Research Provides Initial Answers About the Fate of Trace Organics in Treatment Plants

Activated sludge treatment (an aerobic process) of the primary effluent significantly decreased estrogenicity. More than 90% of most estrogenic trace organic compounds are removed from the liquid phase during activated sludge treatment.

However, the only biosolids stabilization process that reduced estrogenicity was aerobic digestion, in which an 18% reduction was observed. Lime addition resulted in as much as a three-fold increase in estrogenicity, whereas mesophilic and thermophilic anaerobic digestion caused less significant increases. The increase in estrogenicity during anaerobic digestion processes was a consequence of transformation of some of the compounds to an estrogenically potent form. For the plants employing anaerobic digestion, the total estrogenicity leaving the plant in the biosolids was greater than that leaving the plant in the secondary treated effluent; although for the two plants in which plant level estrogenic mass balances could be evaluated, the estrogenicity leaving the plant (liquids plus biosolids) was less than that entering (primary influent).

It was encouraging to note that some digestion processes studied were quite effective at removal of certain classes of estrogenic compounds. The lime stabilization process removed more than 90% of alkylphenol ethoxylates compounds (APEs) in warmer months, although it was less effective during the winter. APEs are referred to as “environmental estrogens” because they have been demonstrated to mimic the effects of naturally occurring hormones and are suspected of causing health effects in both humans and wildlife. A confounding observation was that the total estrogenicity, as measured by the bioassay tests, increased dramatically during lime stabilization. This estrogenicity increase may be contributed to by reactions that are known to increase the estrogenic potency of several other types of estrogenic compounds.

This research significantly adds to our understanding of the fate of trace organic compounds in solids treatment processes. Moreover, it provides important information on the measurement and occurrence of trace organic compounds in biosolids. This information will be used in the next phase of research to determine if there are potential impacts from the trace organic compounds in biosolids-amended soils.

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