SSW 2.2.A.14

Product Title: Develop cost effective field monitoring and laboratory methods to measure groups of contaminants of emerging concern and/or legacy chemicals and pathogens

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Matrix Interface: Blake Schaeffer

ORD Task (as listed in RMS): Task 2.2.A Name: Chemical and Microbial Contaminant Grouping for Evaluating Ecological and Human Health

Suggested ORD Partner Contact/Intended audience for product: OW (Octavia Conerly, Ed Ohanian, Rick Stevens); Region 6 Rick McMillin, Region 1 Peter Philbrook, Region 9 Brenda Bettencourt

Brief Description:

Background

Increasing demands for sources of clean water, combined with changing land use practices, climate change and variability, pose significant threats to our Nation's water resources. The cumulative impact to human health and aquatic ecosystems from the release of multiple emerging contaminants (ECs) (e.g., antibiotics, steroids, hormones, illicit drugs) into the aquatic environment is uncertain. Most levels of ECs detected in the environment are below the toxicity threshold for an acute effect. However, due to the pseudopersistence of many of the ECs it may be possible to elicit an effect from chronic exposure. Chronic exposure, as well as acute exposure, to ECs will likely be of increasing importance in a water commodities-based future where water reuse, and recycling, will play an ever-increasing role, along with the probability of increasing ECs into source water supplies. This research was intended to provide tools (e.g., methods, EPA reports, peer-reviewed publications) to assess and manage risks from anthropogenic emerging contaminants, such as pharmaceuticals

Approach

Analytical chemistry methods were developed to quantify numerous emerging contaminants (ECs), such as pharmaceuticals (i.e., tamoxifen, tamoxifen metabolites, aromatase inhibitors, antibiotics, illicit drugs, over-the-counter drugs) in aqueous samples (wastewater, surface waters), and fish tissue. Also, different environmental sampling techniques were deployed and ground-truthed in the aquatic environment. For example, polar organic chemical integrated samplers (POCIS) were deployed and tested against a traditional grab sampling method. POCIS are specifically designed to sample low concentrations of ECs. The POCIS were calibrated and tested in collaboration with the USGS. One aspect of this project crossed-over to CSS, whereby analytical tools were provided to detect and characterize aromatase inhibitors (AIs, a subset of ECs) and integrate that with cross-species extrapolation through *in vivo* experiments. This research product, over several publications, incorporated several outside

EPA community, academic, and inter-Agency partners: City of Lake Havasu (Arizona), University of Arizona, the State of Oklahoma Department of Environmental Quality, and USGS.

Results

In several of the attached publications, it is demonstrated that the use of log D_{ow} (the pH-dependent *n*-octanol–water distribution ratio that takes into consideration the combination of hydrophobicity and ionogenicity, which is how analytes actually behave in the environment) is a better predictor of the fate of polar ECs into various environmental compartments, than the traditional EPA modeler's use of log K_{ow} (which is not pH-dependent). Using log D_{ow} demonstrates that compounds with higher water solubilities, such as the illicit drugs: methamphetamine, MDMA (Ecstasy), and the over-the-counter (OTC) drug, pseudoephedrine; can travel for several kilometers downstream from the WWTPs. Knowing that ECs can travel far from their initial source can be important for water managers to understand the impact, and cumulative sources of ECs into their source waters. This research also confirmed that some compounds, like azithromycin, methamphetamine, and 4-hydroxytamoxifen, are pseudopersistent; in that they are always present in the waste streams due to their widespread use. This is an especially crucial factor with regards to antibiotics, as more frequently antibiotic resistant bacteria (ARb) are entering into the environment causing outbreaks of ARb, in humans and animals.

Interestingly, it was discovered that there are temporal variations in the release of different ECs at different times of the year, leading to an improved understanding of wastewater treatment technologies that perhaps one day can be tailored more specifically towards certain classes of compounds. Several of the publications also gave valuable data in comparing the usefulness of time-weighted samplers vs. grab sampling techniques; thereby, leading to better environmental sampling techniques in the aqueous environment.

Significance

Several different sampling, extraction and detection strategies were developed, implemented and ground-truthed in real environmental matrices to determine a variety of polar, non-volatile ECs in environmental samples (source water, wastewater). The data from these longitudinal and temporal studies demonstrated that ECs are prevalent even in waters thought to be "pristine" due to anthropogenic incursion of ECs from wastewater treatment plants (WWTPs), and recreational use of those waters. This product demonstrated that the effluents of WWTPs can be a significant source of ECs released into source and drinking water resources. Sources of clean water in the arid southwestern United States (US) are certainly not abundant and more than a decade of drought threatens to limit those sources that exist. A growing number of water management entities have responded by recycling treated wastewater effluent to stretch their current and projected water consumption needs. One research project, coordinated with the City of Lake Havasu, was directed towards water reuse and the implications of using WWTP treated effluent as potential drinking water for future municipal drinking water needs.

Overall, the cumulative impact to human health and aquatic ecosystems from the release of multiple ECs (e.g., tamoxifen, 4-hydroxytamoxifen, antibiotics, steroids, hormones, illicit drugs) into the aquatic environment is uncertain. It can be ascertained that chronic effects for multiple exposures to ECs often do not have visible results and can remain hidden for a much longer time. Chronic exposure, as well as acute exposure, to ECs will likely be of increasing importance in a water commodity-based future where water reuse, and recycling, will play an ever-increasing role, along with the probability of increasing ECs into source water supplies. The data, and methodologies, can give regulators and water management authorities a better understanding of ECs in source waters that are used for habitat management, recreational usage, as well as drinking water resource.

Expected use by partners or others

These products would be of interest to the Office of Water, in respect to an agreement signed with other 10 other government agencies [under the auspices of the National Science and Technology Council Committee on Environment and Natural Resources Toxics and Risk Subcommittee, Pharmaceuticals in the Environment (PEC) workgroup] to coordinate research on pharmaceuticals in wastewater and drinking water. Regions 1, 2, 6 and 9 are interested in occurrence data. Technical expertise developed is currently being utilized in CSS 6.1.2, SSWR 2.4A Hydrofracking, and under SSW Q7 requests for highly targeted programmatic support.

Attachments

1. Jones-Lepp TL "Four Fish Kills Spanning 2011 – 2013 in the Red River Watershed: Beaver Creek to Lake Texoma, Oklahoma," EPA/600/R-14/057, April 2014 (EPA external report)
2. Jones-Lepp TL "Occurrence, effects and methods for antibiotics and illicit drugs in the environment," In: Pharmaceutical Accumulation in the Environment, Goldstein, W (2014) (eds), Taylor and Francis (book chapter)
3. Wilson D, Jones-Lepp TL**,** "Identifying Sources of Emerging Contaminants and Monitoring their Transport in the Subsurface after Effluent Vadose Injection, Lake Havasu City, Arizona**,"** Environmental Engineering and Geoscience, August 2013, XIX (3), pp 231-251 (journal article)
4. Jones-Lepp TL "Interim Report Toolbox of analytical chemistry methods that identify and quantify endrocrine-active pharmaceuticals (EAPs) plus major metabolites in aqueous samples (waste water, surface waters) and plasma.", EPA/600/X/13-255, September 2013 (EPA internal report)
5. Jones-Lepp TL**,** Sanchez CA, Alvarez DA, Wilson D Taniguchi-Fu R "Point sources of emerging contaminants along the Colorado River Basin: Impact on water use and reuse in the arid southwest", Sci Total Environ, 430, 237-245, 2012 (journal article)
6. Alvarez DA, Rosen MR, Perkins SD, Cranor WL, Schroeder VL, Jones-Lepp TL "Role of the upper sediment in the vertical gradient of organic contaminants in Las Vegas Bay, Lake Mead, Nevada," Chemosphere, 88(5), 605-611, 2012 (journal article)
7. Jones-Lepp TL **"**Emerging Contaminants in the Environment," In: Comprehensive Environmental Mass Spectrometry, Lebedev A (2012) (eds), ILM publications. (book chapter)