Advancements in the assessment of micropollutants through the application of broad-scale "down-the-drain" exposure modelling

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Introduction

Municipal wastewater effluent is a major exposure route for a wide range of “down-the-drain” chemicals that are treated and discharged to natural water bodies. Exposure models that focus on estimating concentrations of effluent-associated chemicals receiving waters can serve as a valuable screening-level tool for risk assessment of micropollutants and other potential environmental stressors. iSTREEM®, a web-based model made freely available to the public by the American Cleaning Institute (www.iSTREEM.org), provides a means to estimate concentrations of “down-the-drain” chemicals in effluent, receiving waters, and drinking water intakes across national and regional scales under mean annual and low (7Q10) flow conditions in the United States. The development and evolution of the iSTREEM® model reflects recent trends in technical, conceptual and practical aspects of “down-the-drain” exposure modelling to address current challenges and needs, such as assessment over broad geographies, incorporation of variability, geo-referencing of modelling components, and accessibility and enhanced utility for end-users.

Model Overview

The iSTREEM® model integrates point locations of facilities along a hydrologic network, providing a framework to assess environmental risk in a spatial context using established modeling algorithms such as WJU2 (USEPA).

Wastewater treatment facility (WWTP) characteristics
10,000 facilities (USEPA Clean Watersheds Survey)
Drinking water intakes (DWI)
~1700 intakes (USEPA SDWIS)
Hydrologic network
Mean annual and low (7Q10) flow
~25,000 effluent-impacted river segments (USEPA RF1)

GIS and web integration
Points (WWTP, DWI) are related to hydrologic network. User access via web browser interface for user input, visualization (mapping services), and download of results

Evaluation of exposure model characteristics

Uses for iSTREEM®
• PEC estimation at mean and low flow at national/regional scales
• General guidance for site selection for higher field monitoring (e.g., regions/watersheds most impacted)
• Generating distributions of dilution factors and other information

iSTREEM upcoming enhancements
• Updates and enhancements to meet modeling needs of users
• Updated facility data and transition to more recent and high-resolution flow network (NHDPplus version 2, USGS/USEPA)
• Increased model accessibility, functionality and documentation for users
• Expansion to other geographies (initially Canada)

Model Case Studies

To enhance transparency and interpretation of the iSTREEM® model, a case study was conducted comparing national distributions of modelled concentrations of selected “down-the-drain” consumer product ingredients to available monitoring data at comparable flow conditions.

• Available surface water monitoring data (USGS/USEPA) compiled for three high-volume, widely distributed chemicals - Triclosan - HHCB - DEET
• Subset monitoring data by hydrologic condition (mean, low flow)
• Values for non-detections interpolated using ProUCL software (USEPA)
• Comparison of national concentration distributions

iSTREEM® yielded generally conservative exposure estimates, which can be used to construct an estimation of the distribution of chemical concentrations for effluents and streams. This leads to the selection of a “predicted environmental concentration” (PEC) from the high end of the distribution (e.g., 90th-percentile at low flow) which can be compared to a “predicted no effect” (PNEC) value from ecotoxicological studies.

Conclusions

• iSTREEM® provides a conservative aquatic exposure distribution estimation for “down-the-drain” chemicals used in the United States
• Optimal choice of an exposure model is dependent upon the needs of a specific assessment, from broad geographies to location-specific
• Enhancing understanding and user accessibility provides opportunity to expand and improve models and increase their acceptance as a decision-support tool

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Fig. 1. Modelling challenges and trends
Fig. 2. Data integration
Fig. 3. Schematic of web integration
Fig. 4. Modeled concentrations displayed in user interface
Fig. 5. DEET monitoring data
Fig. 6. Concentration distribution results (blue dash= iSTREEM mean flow, red dash= iSTREEM low flow, black points= field data mean flow, gray points= field data low flow, vertical yellow line= PNEC, horizontal yellow line= 90th percentile)
Fig. 7. Triclosan, low flow

Table 1. Model PEC, field data, and PNEC

*Highest 90th value from filtered or unfiltered used HHCB effluent analysis.
†HHCB (Yoshida et al., 2013)
‡PNEC used for triclosan (USEPA 2012).