A scientific workflow to estimate non-occupational 1,4-dioxane exposure pathways from drinking water and product use

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United States Environmental Protection Agency

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Introduction

- 1,4-Dioxane is an industrial chemical and is an unintended byproduct in multiple consumer products via ethoxylated ingredients
- It is persistent and mobile in the environmental
- USEPA has identified some unreasonable occupational risks
- People may also be exposed through non-occupational pathways
  - Consuming drinking water contaminated with chemical
  - Using consumer products contaminated with the chemical
- To date, assessments of these pathways have been limited.

Objectives

- Create workflow to estimate 1,4-dioxane exposure to humans and mass released down drain
- Include drinking water and consumer produce use pathways
- Produce quantitative estimates of 1) human exposure, 2)mass released down the drain, and 3) relative source contributions
- Evaluate potential intervention strategy to reduce exposure and mass release down the drain

Methods

- Workflow designed around the EPA exposure simulation tool **SHEDS-HT (Figure 1)**
  - Sources
    - Contaminated drinking water
    - Use of contaminated consumer products (5 classes)
  - Outputs
    - Human Exposure (mg/kg/day)
    - Mass released down the drain (g/day)
  - Exposure/down the drain evaluated using factorial design
    - Water *source:* Groundwater (GW), Surface water (SW), Mixed Sources (MX)
    - Geographic *scale:* US National (US) or state of California (CA)
    - Prevalence of 1,4-dioxane in product classes: High or Low
    - Parsed outputs by exposure population
      - Total population (some people without contaminated water)
      - Subset for which water contamination always occurs
- Evaluated product concentration threshold mitigation strategy
- SHEDS-HT customizations to better reflect exposure scenarios
  - Better aligned exposure/release activities with sources
  - More realistic product use patterns

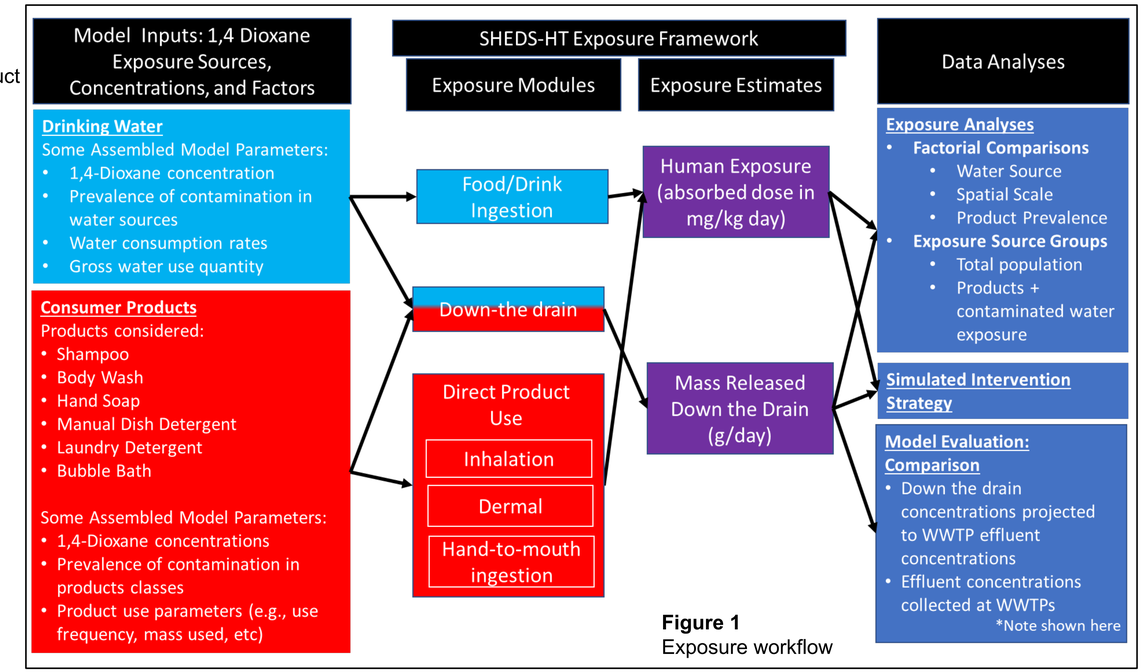


Figure 1
Exposure workflow

Figure 2 Proportion of human exposure due to water consumption in Total population (A) and subset of population in which water contamination always occurs (B)

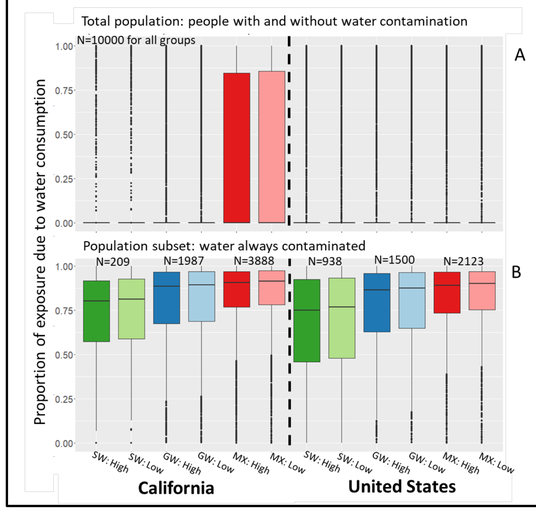
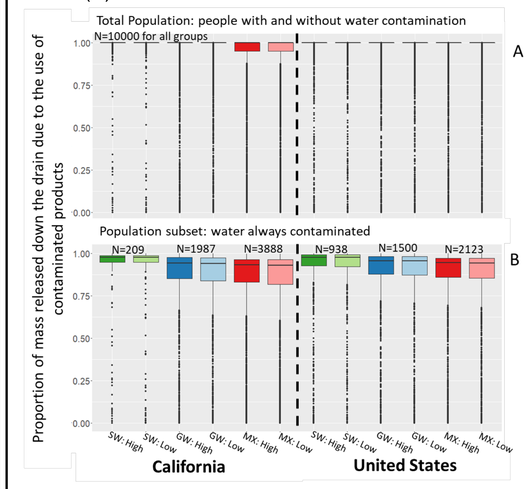


Figure 3 Proportion of mass released down the drain from use of consumer products in Total population (A) and subset of population in which water contamination always occurs (B)



Results

Estimated Absorbed Dose
- Median: 3.57 x 10^{-7} mg/kg/day
- Min: 2.29 x 10^{-7} mg/kg/day
- Max: 4.27 x 10^{-6} mg/kg/day

Estimated Per Capita Mass Released Down the Drain
- Median: 9.70 x 10^{-4} g/day
- Min: 7.91 x 10^{-4} g/day
- Max: 1.86 x 10^{-3} g/day

- Factorial analysis
  - Minor impacts of considered factors on exposure or mass release down the drain
  - Source contributions
    - Human exposure: Water consumption is primary source when water is contaminated **(Figure 2)**
    - Mass released down the drain: Consumer product use is primary source regardless of water contamination status **(Figure 3)**
- Simulated intervention strategy
  - Largest reduction in exposure when water contamination is low
  - Broadly reduced mass release down the drain, regardless of water contamination status

Conclusions and Discussion

- Water contamination status a key consideration for exposure
  - Hard to interpret source contribution for Total population due to low prevalence of water contamination overall
  - Water consumption clearly drives exposure when water contamination occurs
- Product use clearly drives mass released down the drain regardless of water contamination status
- Exposure intervention approaches aimed at reducing product concentrations may have the largest impact for populations primarily exposed via product use
- Important Study Limitations
  - Ultimate sources of water contamination and impacts of mass released down the drain on drinking water concentrations not determined here
  - The list of product classes included in assessment was not exhaustive; i.e., model estimates may be underestimates
  - Exposure estimates likely not reflective of areas with high drinking water concentrations

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*References provided upon request