Homegrown Produce Consumption Impacted by Contaminated Irrigation Water: An Evaluation of Available Methodologies to Calculate Exposure

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Introduction

Lack of Standardized Guidance

The U.S. Environmental Protection Agency (EPA) provides standardized approaches to evaluate chemical exposures through pathways such as drinking water ingestion and soil contact. However, no federal guidance exists for assessing risk from consuming homegrown produce irrigated with contaminated water. Some state agencies have developed methodologies, but there is no standardized approach.

Study Objective

The goal of this study was to evaluate existing methodologies to assess homegrown produce consumption impacted by contaminated irrigation water and aimed to provide recommendations for best practices in screening-level calculations.

Methods

Comparison of Approaches

We reviewed the following agency derived irrigation water screening level methodologies:

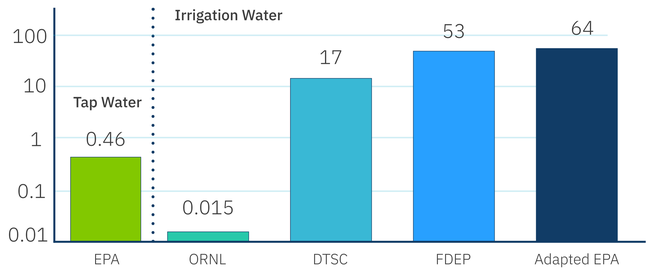
- California Department of Toxic Substances Control (DTSC)
- Florida Department of Environmental Protection (FDEP)
- Oak Ridge National Laboratory (ORNL)
- EPA Combustion Guidance - Adapted Approach (EPA)

Using these methodologies, we implemented the following considerations when calculating irrigation water screening levels for 1,4-dioxane:

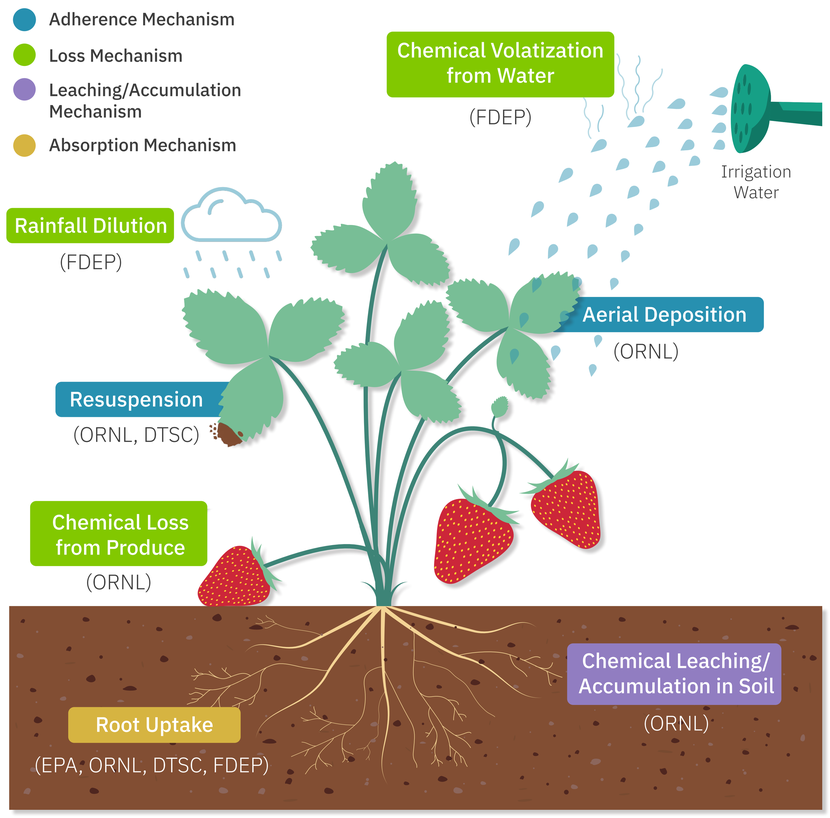
- The irrigation water screening levels are based on standard exposure assumptions for a residential receptor assuming an excess lifetime cancer risk of $1x10^{-6}$ and hazard index of 1.
- We used the recommended produce ingestion rates specific to each model.
- The adapted EPA approach only considers root uptake; however, additional mechanisms are considered by EPA in the Combustion Guidance.
- The FDEP and ORNL models directly calculate an irrigation water screening level. The DTSC and EPA soil models were adapted to calculate an irrigation water screening level.

We compared the calculated screening levels and identified key factors contributing to the different screening level outcomes. Our evaluation focused on model assumptions, strengths, and limitations.

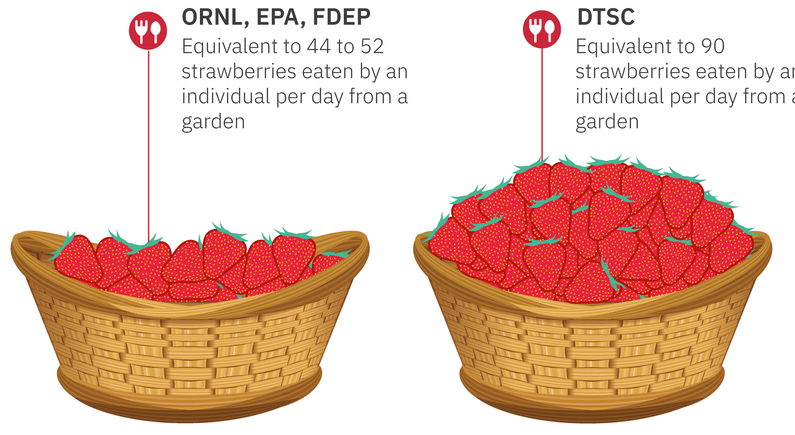
1,4-Dioxane Tap Water and Irrigation Screening Levels (µg/L)



Chemical Absorption, Adherence, and Loss Mechanisms



Produce Ingestion Rate Comparison



Results

Key Findings

- The DTSC, FDEP, and adapted EPA models produced relatively similar screening levels for 1,4-dioxane.
- The ORNL approach yielded a screening result several orders of magnitude lower than other methods. The ORNL irrigation water screening level is much lower than the tap water screening level, which assumes someone drinks contaminated water directly.

Key modeling variables that result in a low ORNL irrigation water screening level include:

- The default soil leaching rate is low, likely overestimating the degree to which 1,4-dioxane accumulates in the soil and consequently in the plant.
- When the default soil leaching rate was replaced with the chemical-specific rate for 1,4-dioxane, the screening level increased two orders of magnitude.
- The model assumes aerial deposition and resuspension, which increases the amount deposited on the plant thus increasing the potential for exposure.

Additional differences that impact the outcome of the modeling results are due to the following:

- FDEP and ORNL consider contaminant loss mechanisms in the modeling approach, which can result in higher screening levels. However, ORNL also considers conservative adherence mechanisms, which reduce the screening level.
- The FDEP and adapted EPA approach assume different root uptake factors for root vegetables and above ground produce. The ORNL and DTSC models only use one root uptake factor for all plant types.

Discussion

Impact Due to Derivation Differences

- Significant discrepancies in screening levels highlight the importance of careful parameter selection and model calibration.
- The use of default values instead of chemical-specific parameters in the ORNL approach results in overly conservative exposure estimates.
- Model results may vary significantly depending on the contaminant assessed, making it difficult to generalize findings across different chemicals.

Future Direction

Improving Model Accuracy and Reliability

- Method selection critically impacts exposure estimates, underscoring the need for reviewing underlying assumptions.
- Further standardization and refinement of methodologies are needed to improve accuracy and reliability in assessing risks associated with homegrown produce irrigated with contaminated water.

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Method selection and assumptions greatly impact **risk estimates for homegrown produce irrigated with contaminated water**, emphasizing the need for **standardized approaches** to improve accuracy and reliability in exposure assessments.

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