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Emerging Contaminants WASTE management SYSTEM ("ECWM") for Agriculture Application

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Abstract

Recent reporting of occurrence of emerging contaminants (i.e., ECs), such as engineered nanoparticles, pharmaceuticals, personal care products and endocrine-disrupting chemicals in wastewater has increased public attention and poses concerns during agriculture -based reuse applications of wastewater residuals. This study proposed an integrated waste management system for handling ECs pollution in wastewater by linking ECs fate in water and sludge to treatment requirements for reuse applications (termed as "ECWM", hereafter) using the mass-balance approach. Parameters describing ECs fate in every unit process were identified. Efforts are underway to populate the ECs parameter database first which can be used in running this model for different ECs.

Keywords: Emerging contaminants; Fate; Reuse; Waste management system.

1. Introduction

Recent reporting of occurrence of emerging contaminants (i.e., ECs), such as, engineered nanoparticles (Kiser et al., 2009), pharmaceuticals, personal care products and endocrine-disrupting chemicals (Kumar and Xagoraraki, 2010;Gao et al., 2012) in wastewater and natural bodies poses concerns during agriculture -based reuse applications of wastewater residuals. Considering potential health risks, there is a need for managing wastewater treatment residuals with regards to these ECs in an integrated manner. Although some studies have modeled fate of different types of ECs (Struijs et al., 1991; Heidler and Halden, 2008; Gottschalk et al., 2009; Gao et al., 2012; Singh and Kumar, 2013), there lacks an integrated model which connects ECs from wastewater treatment plant (WWTP) to reuse applications ends. The objective of this study was to propose an integrated waste management system for handling ECs pollution to minimize health risks during agriculture-based reuse applications.

2. Methodology

A theoretical framework was proposed to develop emerging contaminants waste management system by simulating the fate of ECs in different WWTP unit processes and environmental media using a mass-balance approach (i.e., "ECWM", hereafter). Parameters describing ECs fate in every unit process were identified.

3. Results and Discussion

The schematic of the proposed ECWM is shown in Figure 1. This framework predicts concentrations of ECs in different exposure media from where human exposure can happen, i.e., groundwater, contaminated soil, stream water, and edible plants. In WWTP, concentrations of ECs in water stream depend on their solubility in water, settling characteristics, biodegradability, and tendency to adsorb on inert particle surfaces as well as on biological materials. These factors finally determine remaining concentrations of ECs in water and solid medium. For example, fate of TiO_2 nanoparticles in primary sedimentation tank depends on its settling rate which is generally very small and thus it takes very long time for particles to settle down. In biological unit process, due to poor solubility, most of the NPs are retained in solid matrix (i.e., trapped and/or adsorbed on material surface) and thus finally partition into solid medium. Thus remaining concentrations of NPs in water medium is relatively smaller than that in solid medium (i.e., in sludge). To predict portioning of NPs and other ECs on solid medium, information about their adsorption capacity are required which is being compiled into a parameter database. Now, wastewater residuals (i.e., effluent and sludge) are discharged to surface water, disposed in landfills and/or land applied as fertilizers. In these environmental compartments, concentrations of ECs decrease due to compartmental effects (dilution, biodegradation and adsorption). In the event of possibility of leaching due to rain, some of these ECs might leach out from landfill (or from soil surface) and might contaminate groundwater and surface water (exposure routes: R1, R4 and R5; Figure 1). Resultant concentrations of ECs in groundwater and surface water depend on ECs interaction with soil, subsurface soil and biodegradation and adsorption potential. Sludge applied on land surface can also be inadvertently ingested and thus this route can also contribute to oral exposure health risks (exposure route: R3; Figure 1). Further, surface water used for irrigating edible plants might contaminate plants with ECs where ECs might be absorbed in different parts of plants. Consumption of edible plants might result in exposure of ECs inadvertently (exposure route: R2; Figure 1). In each of these compartments, ECs are taken by compartment and some fraction of it is transferred to next compartment which depends on compartment uptake capacity and ECs biodegradation and adsorption in a given compartment.

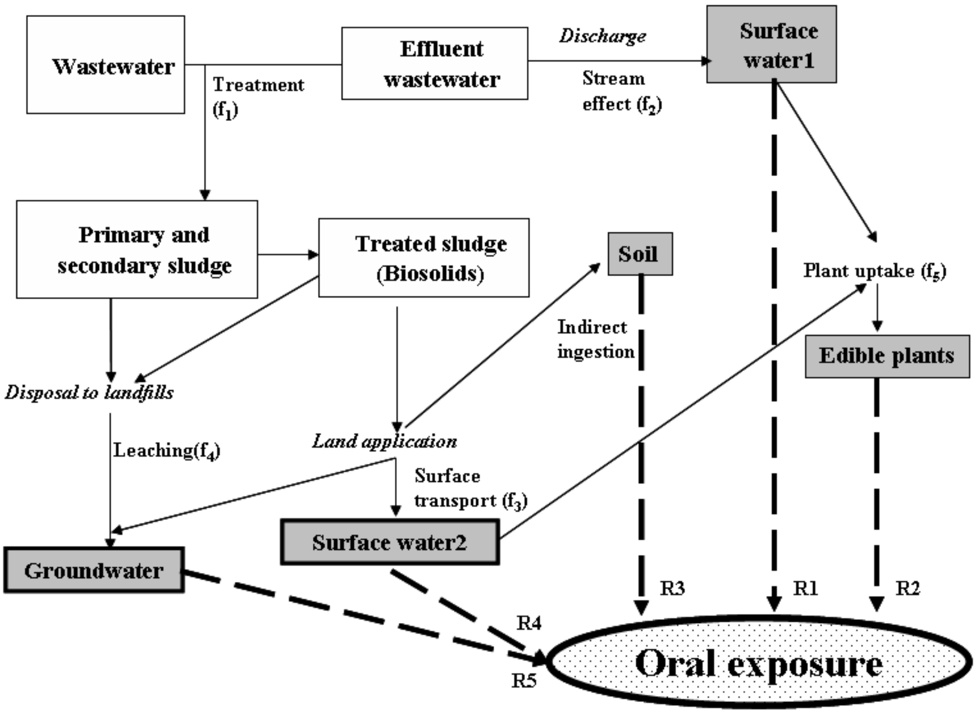

Figure 1: A schematic of the proposed integrated framework ("ECWM") linking inadvertent human exposures of ECs to their fate in wastewater treatment plants (f: transfer coefficient; R-exposure route).

4. Summary and Conclusions

This study proposed an integrated waste management system ("ECWM") for handling ECs pollution to minimize health risks during agriculture reuse applications. Parameters affecting fate of ECs in WWTP and in environmental compartments were identified. Further efforts are underway for populating values of these parameters for different ECs which would aid in running the proposed ECWM for risk-management purposes.

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