Leaching of Pharmaceutical and Personal Care Products (PPCPs) and Disinfection By-Products (DBPs) in Turfgrass Soils Irrigated with Reclaimed Water

J. Xu, W. Chen, L. Wu, R. Green, and A.C. Chang

Department of Environmental Sciences, University of California, Riverside and UC Center for Water Resources

Introduction

The practice of using reclaimed wastewater for landscape irrigation has been employed for many years in many parts of the world. Reclaimed wastewater typically contains trace contaminants, including steroid hormones, pharmaceuticals and personal care products (PPCPs), and disinfection byproducts (DBPs). Their fate and transport in the vadose zone, however, are essentially unknown. This work is to evaluate the fate and transport of 17 selected PPCPs and DBPs commonly found in the reclaimed water in a turfgrass system.

Experimental Setup

In the study, a leaching experiment was conducted at the experimental fairway facility at the University of California, Riverside. Irrigation water was spiked with PPCPs and DBPs and mixed thoroughly in a 5000-gallon tank. Two irrigation rates (1.1~1.2ET_0 and 1.4~1.5ET_0) were applied to two soil types (sandy loam and loamy sand) and the treatments were replicated three times (12 plots). In order to determine the effect of grass on the leaching behavior of the chemicals, grass in another set of four plots (two for each soil type) was removed to create a bare soil condition. Leachate was collected after each irrigation (twice a week) and analyzed for the targeted compounds. Finally, composite soil core samples from each plot were collected, sliced and analyzed for the compounds to determine their distribution in the soil profile 4 months after the initiation of the experiment.

Experimental facility

The leach facility consists of 24 plots, each with 3.66 m x 3.66 m of surface area. Half of the plots were filled with a native fine sandy loam (67.3% sand, 19.8% silt, and 12.9% clay) and the remaining plots with an imported medium-fine sand (98.4% sand and 1.6% silt and clay). A lysimeter assembly (Fig. 1), consisting of five metal cylinders with a combined surface area of 1.23 m^2, was pre-assembled and installed at the center of each plot. The top soil layer is 89 cm deep, with a 7.5 cm of gravel layer at the bottom to facilitate gravity drainage and leachate collection.

Compounds Tested

Clofibric acid	Diclofenac-Na
Ibuprofen	Bisphenol A (BPA)
4-tert-octylphenol	Estrone (E1)
4-n-nonylphenol	17 β -estradiol (E2)
Naproxen	17 α -ethynylestradiol (EE2)
Triclosan	

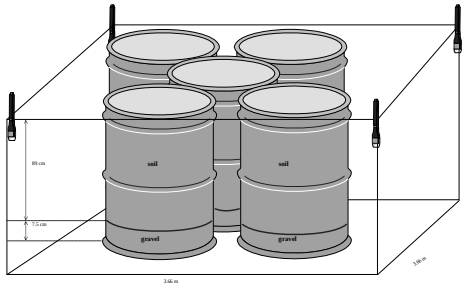

Fig. 1. Lysimeter assembly.

Fig. 2. Experimental site at UCR Turf Research Facility.

Analytical Methodology

Analysis of soil

One liter of water sample → 0.70 um GF filter → pH adjustment to 3 → loading to C18 SPE cartridge → eluted with ethyl acetate → derivatization with MTBSTFA →GC/MSD.

Analysis of leachate

Five grams of soil sample → ultrasonic solvent extraction with mixture of acetone and ethyl acetate → extracts concentrated → extracts re-dissolved in 500 ml of deionized water → SPE cleanup → derivatization → GC/MSD

Results

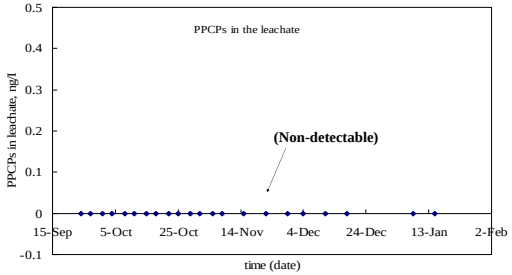

Fig. 3. PPCPs in leachate.

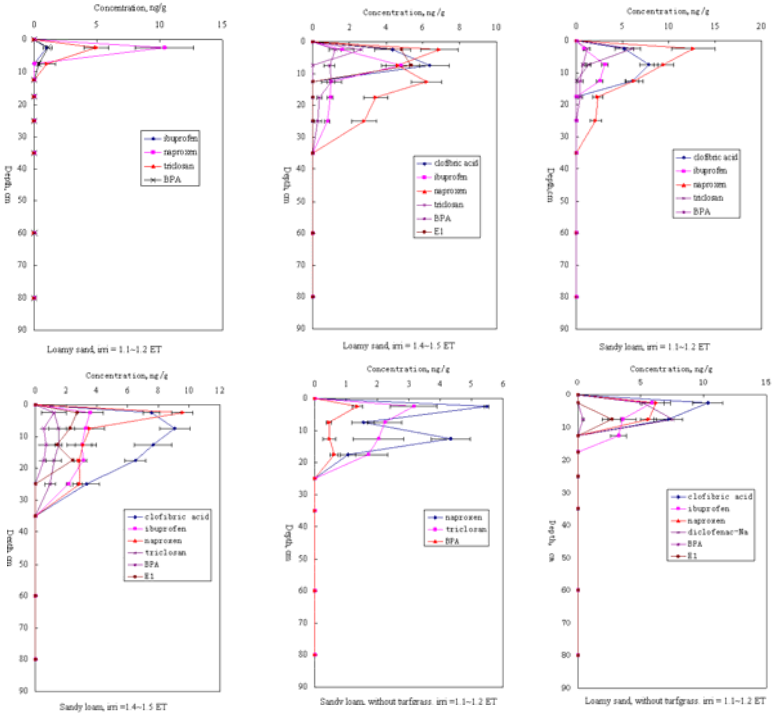

Fig. 4. Distribution of selected compounds in soil profiles.

Conclusions

During the 125-d irrigation experiment, no PPCPs or DBPs were detected in the leachate.

- Most of the compounds stayed in the top 5-15 cm soil profile.
- High irrigation rate (1.4~1.5 ET) enhanced the downward movement of the compounds in turfgrass soil; thus more chemical species were found in deeper layers under heavy irrigation.
- Some chemicals, such as 4-tert-octylphenol, 4-n-nonylphenol, E2, and EE2, were not found in soil samples, which was attributed to fast degradation.
- Under bare soil condition, fewer chemicals were found in the sandy loam than in the loamy sand, indicating that dissipation of some chemicals was faster in the sandy loam soil.
- The chemical species and amounts found in bare plots were less than those in plots with turfgrass cover, suggesting that photolysis may be an important degradation pathway for these compounds.
- Our results showed that leaching of PPCPs and DBPs to groundwater is unlikely when reclaimed wastewater is used for normal turfgrass irrigation.