PHARMACEUTICAL COMPOUNDS IN SOILS IRRIGATED WITH RECLAIMED WASTEWATER: FATE IN THE AGRO-ENVIRONMENT

Benny Chefetz, *Department of Soil and Water Sciences, The Hebrew University of Jerusalem, Israel*
Oshri Burgman, *Department of Soil and Water Sciences, The Hebrew University of Jerusalem, Israel*
Ran Yakir, *Department of Soil and Water Sciences, The Hebrew University of Jerusalem, Israel*
Haniella Harush, *Department of Soil and Water Sciences, The Hebrew University of Jerusalem, Israel*
Moshe Shenker, *Department of Soil and Water Sciences, The Hebrew University of Jerusalem, Israel*

Background and Aims: Irrigation with reclaimed wastewater accounts for more than 50% of total irrigation water in Israel. This unique situation of intensive irrigation with reclaimed wastewater and sludge application containing residues and active pharmaceutical compounds (PCs) provides an excellent opportunity to study the long-term exposure effects of these compounds in soils. The long-term introduction of PCs to arable land may affect the agro-ecosystem in various aspects which are not known to date. In this study we aimed to elucidate the behavior (transport, sorption-desorption and plant uptake) of pharmaceutical compounds in the agro-ecosystem and to evaluate the potential transport of the compounds to groundwater and more importantly to enter the food-chain via crops.
Methods: All the studied compounds were detected in reclaimed wastewater used for crop irrigation. Transport and sorption experiments were performed with soil layers sampled from a plots that have been irrigated with reclaimed wastewater for long period. Uptake by plants was studied in hydroponic greenhouse experiments using different soil types irrigated with fresh water or reclaimed wastewater
Results: Carbamazepine and diclofenac were significantly retarded in the 0-5 cm soil sample rich in soil organic matter. Carbamazepine was not affected by the water quality (freshwater vs. reclaimed wastewater), whereas diclofenac exhibited a higher retardation factor (RF) in the freshwater system. Naproxen exhibited significantly lower RFs than diclofenac but with a similar trend—higher retardation in the freshwater versus reclaimed wastewater system. In the 5-15 cm soil sample containing low soil organic matter, naproxen was highly mobile while carbamazepine and diclofenac were still retarded. In the 15-25 cm sample, all compounds exhibited their lowest RFs. The antibiotics sulfamethoxazole and sulfapyridine exhibited high mobility under both fresh and wastewater application and were not affected by sludge application.
Carbamazepine concentration in cucumber fruits and leaves was negatively correlated with the level of organic matter in the growing medium. The concentrations of carbamazepine in the roots and stems of cucumber plants were relatively low; most of it (76-84% of total uptake) was detected in the leaves. A greenhouse experiment using fresh water and reclaimed wastewater spiked, or not, with carbamazepine at 1 $\mu g\ L^{-1}$ (typical concentration in effluents) revealed that it can be taken up and bio-accumulated from its indigenous concentration in reclaimed wastewater. Our experimental data in hydroponic culture suggest that the uptake of carbamazepine can be considered passive and unrestricted and the translocation is governed by water mass flow; therefore, in the greenhouse experiments, the bioaccumulation factor for the fruits was significantly lower than the value calculated for the leaves.
Conclusions: Our data suggest that carbamazepine and diclofenac can be classified as slow-mobile compounds in soil organic matter-rich soil layers. When these compounds pass this layer and/or introduced into soil organic matter-poor soils, their mobility increases significantly (Chefetz et al., 2008). Other compounds based on their physico-chemical properties can be considered as highly mobile in soils. This study emphasizes the potential uptake of active pharmaceutical compounds by crops in organic-matter-poor soils irrigated with reclaimed wastewater and highlights the potential risks associated with this agricultural practice (Shenker et al., 2011).

References

Shenker, M., D. Harush, J. Ben-Ari and B. Chefetz. 2011. Uptake of carbamazepine by cucumber plants – A case study related to irrigation with reclaimed wastewater. Chemosphere 82:905-910.

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