

Numerical Analysis of Fate and Transport of Pharmaceutical Residue Ketoprofen and Its Transformed Products in Paddy Soils

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Ketoprofen (KPF), one of the analgesic antipyretic drugs, has been found in treated wastewater due to incomplete removal of pharmaceutical compounds at wastewater treatment plants. Although its toxicity to the aquatic ecosystem is relatively known, that of its transformed products is relatively unknown. Recycling of treated wastewater in agriculture becomes inevitable as demand of freshwater is growing due to global population explosion. In a part of Ehime prefecture, Japan, some paddy fields have been irrigated with treated wastewater. However ecotoxicity of using treated wastewater has not been fully investigated.

In this study, the fate and transport of KPF and its transformed products in a paddy field was numerically investigated. Transport characteristics of KPF and its transformed products in saturated soil were obtained from the column experiment. Numerical simulation of fate and transport in paddy soil was conducted using HP-1 program, which is a coupled program of HYDRUS-1D and PHREEQC, so that different degradation paths can be taken into account. To mimic the surface ponding, a two layer model was constructed where the top 5-cm layer was used for surface ponding. In this layer, photolytic degradation of KPF with two different known daughter products was considered. In the lower layer, which is a 15-cm plow layer, biodegradation with two different known daughter products was considered. Photolytic degradation depends on the proportion of light intercepted by growing rice. In this study, different scenarios for light interception, from no interception to full interception, were considered. When 50 % or more light is intercepted, KPF was completely degraded by solar in surface ponding and the photodegraded products may reach at the bottom of the plow layer. The concentrations of both of transformed products were much lower than that of KPF in irrigation water. On the other hand, when light is completely intercepted, the 50 % of KPF in the soil will be degraded before reaching to the bottom of the plow layer. The concentration of biotransformed products at the bottom of the plow layer will be two or three orders of magnitude less than the input concentration of KPF. This study investigated numerically the risk of using treated wastewater for paddy. Our results indicated that, depending upon the growing period, different transformed products may be leached out from the plow layer. More ecotoxicity study may be necessary for transformed products of KPF.

Keywords: Treated Wastewater, Paddy, Ketoprofen, Transformed Products, Fate, Numerical Analysis