Effect of Feeding Strategies on Pharmaceutical Removal by Subsurface Flow Constructed Wetlands

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This study presents findings on an assessment of the effect of continuous and batch feeding strategies on the removal of selected pharmaceuticals from synthetic wastewater. Six mesocosm-scale constructed wetlands, including three horizontal subsurface flow constructed wetlands and three sand filters, were set up at the campus of Nanyang Technological University, Singapore. The findings showed that ibuprofen and diclofenac removal in the wetlands was significantly (p < 0.05) enhanced in the batch versus continuous mode. In contrast, naproxen and carbamazepine showed no significant differences (p > 0.05) in elimination under either feeding strategy. Our results also clearly showed that the presence of plants exerts a stimulatory effect on pharmaceutical removal for ibuprofen, diclofenac, and naproxen in batch and continuous mode. Estimation of the quantitative role of this stimulatory effect on pharmaceutical elimination of batch operation as compared with the effect of the presence of the higher plant alone showed that batch operation may account for 40 to 87% of the contribution conferred by the aquatic plant. The findings of this study imply that where maximal removal of pharmaceutical compounds is desired, periodic draining and filling might be the preferred operational strategy for full-scale, subsurface flow constructed wetlands.

PHARMACEUTICALS are regarded as emerging contaminants that are continuously introduced into the environment (Ternes, 1998; Stumpf et al., 1999; Matamoros and Bayona, 2006). However, research on the fate and effects of pharmaceuticals in the environment has been limited because they typically occur at trace levels and because until recently there has been a lack of suitable sensitive methods of analysis. Because wastewater treatment plants (WWTPs) are not designed for pharmaceutical compound removal (Joss et al., 2006), many pharmaceutical compounds are released from urban WWTPs into receiving water bodies (Buser et al., 1998; Stan and Heberer, 1997). Finally, drinking water production may be influenced when river water or bank filtered water is the raw water source (Heberer, 2002).

Technologies including ozonation (Huber et al., 2005), reverse osmosis (Kimura et al., 2009), advanced oxidation processes (Ternes et al., 2003), and process optimization in WWTPs (e.g., increasing sludge residence time) (Carballa et al., 2007) reduce the level of pharmaceuticals compounds in water; however, such treatments have not been widely used due to the high costs involved (Heberer, 2002).

Constructed wetlands (CWs) are growing in popularity as a low-impact and economical alternative for purifying contaminated waters. Indeed, CWs have the potential for removing a large variety of emerging organic pollutants (Matamoros et al., 2005; Matamoros et al., 2007). However, relatively little work has been conducted focusing on the removal of pharmaceuticals in CWs (Matamoros and Bayona, 2006).

Many factors can affect the major treatment mechanisms and overall fate of pharmaceuticals in CWs. Previous research has been performed on the design parameters that can affect pharmaceutical removal efficiencies, including types of CWs (Hijosa-Valsero et al., 2010a; Matamoros et al., 2007), plant species (Hijosa-Valsero et al., 2010b; Matamoros et al., 2008b), the depths of sand (Matamoros and Bayona, 2006), seasonal