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Assessing the efficiency of constructed wetlands in removing PPCPs from treated wastewater and mitigating the ecotoxicological impacts

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A B S T R A C T

The prevalence of pharmaceuticals and personal care products (PPCPs) in municipal wastewater has led to increased concerns about their impact on both human health and ecosystem. The constructed wetlands have been recognized as one of the cost-effective and green mitigation approaches to remove the PPCPs in the municipal wastewater. In this study, the effectiveness of a full scale constructed wetlands treatment system (CCWTs) in removing the 36 PPCPs was investigated. The load mass of PPCPs discharged by the wastewater treatment plant into the CCWTs was calculated. Removal efficiencies of PPCPs were evaluated based on physico-chemical properties such as octanol-water partition coefficient (Log k_{ow}), molecular weight (MW, g mol^{-1}) and the acid dissociation constant (pK_a). The CCWTs are especially efficient in removing azithromycin, sertraline, tolfenamic acid, and diphenhydramine with removing efficiency >88%. However, the removal efficiencies of PPCPs in CCWTs exhibit a large variability, depending on physical and chemical properties of the molecules, with 4.7–96.7% for antibiotics, 5–86% for antidepressant and antiseizure drugs, 3.5–88% for NSAIDs, 29–77% for β-blockers and statins and 5.5–94% for other types of PPCPs. In addition, the environmental risk assessment showed that majority of the PPCPs (excluding sulfamethoxazole) in the effluent yielded low aquatic risk (risk quotient, RQ ≤ 0.1) due to the efficiency of CCWTs. The toxicity index scores were calculated by integration of the predicted and available toxicological hazard data into the prioritization ranking algorithm through Toxicological Prioritization Index (ToxPi).

1. Introduction

The prevalence of pharmaceuticals and personal care products (PPCPs) in aquatic environments is the result of direct human disposal and other personal care uses. This has led to increased concerns about their impact on both human health and ecosystem (Larsen et al., 2019; Oulton et al., 2010). Because of the persistence and inherent ability to induce physiological effects in humans at low doses, PPCPs have been classified as emerging pollutants, and have raised increasing concern over the last decade (Zhang et al., 2014). The PPCPs often contain a large group of chemicals with different physio-chemical properties and structures (Ebele et al., 2017). These include pharmaceutical products (e.g., painkillers, antibiotics, anti-allergic drugs, anti-inflammatory drugs, hormones, and β-blockers) which are used to treat diseases in both humans and animals, along with personal care products (e.g., sunscreens, makeup, deodorant, insect repellants, hand soap, and moisturizers) which are used primarily to enhance the quality of life (Abdallah et al., 2019).

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