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Pharmaceutical active compounds removal by constructed wetland systems

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Abstract

This work aims to provide further knowledge on the Pharmaceutical Active Compounds (PhACs) removal efficiency by constructed wetlands systems (CWSs). PhACs support matrix adsorption rate and plant uptake will be tested in isolated experiments to evaluate the removal potential of each of this CWs components. These results will also be used to discuss the hypothesis of using the CWS concepts in river water quality preservation.

Keywords: Constructed wetland; Furosemide; PhACs; Pharmaceuticals; Phytoremediation.

Introduction, scope and main objectives

The detection of pharmaceutical active compounds (PhAC) in the aquatic ecosystems has been recently the focus of an emerging concern. In the last two decades start to appear numerous studies showing an extensive detection of various pharmaceuticals in the environment, as also a outcome of the recent improvements in the analytical detection technology that allowed detecting of these elements down to trace levels (ng/L or µg/L).

The main enter path for these PhACs in aquatic system are through the human and animal excretion released from wastewater treatment plants (WWTP). These pollutants are considered pseudo-persistence since they are continuously delivered in the environment in low concentration rates, leading to an extensive long-term exposure of their effects in the ecosystems. In Portugal, several studies show the presence of these contaminants in surface water, groundwater and in wastewater treatment plants (WWTP) effluents (Gaffney et al., 2014; Pereira et al., 2015; Salgado et al., 2010). To the author's current knowledge, in Brazil no studies have been made on these thematic.

Many PhAC have been found in the discharge effluents from WWTP around the world, showing that these facilities cannot remove mostly of these compounds (Behera et al., 2011; Elorriaga et al., 2013; Jelic et al., 2011). Some studies showed that the combination of different removal techniques in the WWTP can bring a higher reduction rate of these compounds (Muz et al., 2013; Secondes et al., 2014). With the currently European economic crisis, political government representatives are increasingly putting more pressure to reduce costs associated to municipalities management.

Henceforth, the addition of these advanced treatments combined with the present conventional ones is not an optimal solution since it will represent a high economical cost to an already expensive process.

Constructed wetlands systems (CWS) appear as a natural low cost alternative technique for removing pollutants since they present low operational and maintenance costs. CWSs have been used as a phytoremediation technique to remove pollutants, presenting good results on reducing nutrients as well as metals (Luederitz et al., 2001; Maine et al., 2006; Vymazal, 2007; Langergraber et al., 2009; Martín et al., 2013). Thus, studying the capacity of this technique to remove other more persistent pollutants, as PHACs, is an expected path to explore. In the last years, some works start to appear around the globe to answer this gap, showing promising results as can been see in the review article Verlicchi and Zambello (2014). Focusing on Portugal, this topic becomes scarcer and appears only in the works of Dordio et al., (2009a) and (2010), which shows CWSs as a potential phytoremediatian technique for the removal of PhACs. However, some main key questions are still unanswered and the present study aims to answer through laboratory microcosm constructed wetland experiments: Can a CWS remove the PhACs from the two pharmaceitical groups with the highest consumption rates in Portugal and Brazil? Are CWSs maintenance viable? Therefore, the main objective of this work is is to improve the knowledge in the viability and efficiency of constructed wetland systems as a phytoremediation technique to reduce and/or eliminate pharmaceutical active compounds (PhACs) from wastewater treatment plants (WWTPs) effluents. In order to achieve the objective a two-fold research will be addressed, the PhACs retention and removal capacity of selected: (i) support matrices and (ii) wetland riparian plants. The effectiveness of the treatment technique will be tested for PhACs through a constructed wetland microcosm experiments (Dordio et al., 2010). Furthermore, from the results obtained, it is expected to be able to predict the viability of wetland riparian buffer zones to minimize PhACs environmental impact on river water bodies.

Methodology

The methodology of this work is divided in three different experimental trials to study the CWS efficiency for PhAC removal: support matrix adsorption (trial 1), plant uptake (trial 2) and CWS pilot (trial 3). On trial 1, different concentrations will be tested for the selected PhACs, and a control. The concentration will be selected through bibliography review and taking in account the PhAC solubility properties. Photodegradation and microorganism activity will be avoided. The experimental design will be according to Dordio *et al*. (2007). The matrix properties will also be characterized.

Trial 2 will be conducted on the same conditions and using the same PhAC concentrations according to Dordio *et al.* 2009b. The results of this two experiments will be used to optimize the pilot CWS experiment (trial 3). This system will work with a subsurface flow and on a batch mode (Vymazal and Kröpfelová, 2008; Dordio *et al.* 2010). Photodegradation and microorganisms activity won't be avoided in this last experiment, since the objective is to simulate real scale CWS characteristics,allowing to achieve a more comprehensive perspective in the integrated removal mechanisms of CWS for the PhACs.

Finally, the results achieved in the described experimental work will support the hypothesis of using wetland riparian buffer zones in vulnerable systems as well as their implementation on bioengineering river restoration practices.

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