Removal processes of pharmaceuticals in constructed wetlands

A. Dordio [a,b*], A. J. P. Carvalho [a,c]

[a] *Chemistry Department, School of Sciences and Technology, University of Évora, Évora, Portugal.*

[b] *MARE – Marine and Environmental Research Centre, University of Évora, Évora, Portugal.*

[c] *CQE – Évora Chemistry Centre, University of Évora, Évora, Portugal.*

** Corresponding author: Tel: +351 - 266 745343; E-mail address: avbd@uevora.pt*

ABSTRACT

Over the latest years the occurrence of pharmaceutical residues in the environment has been motivating an increasing concern over the possible harmful effects of many of these pollutants to living organisms. In fact many reports are available in the literature about the detection of several of the most consumed pharmaceuticals, their metabolites and transformation products in wastewaters as well as surface and ground waters and even in drinking waters worldwide. This situation can be attributed to the general inadequacy of the conventional treatment processes used in wastewater treatment plants (WWTPs) in dealing with trace pollutants.

The reason for the low efficiencies of conventional WWTPs for removal of pharmaceuticals is the fact that these plants were designed to remove bulk constituents of wastewater such as suspended solids, dissolved biodegradable organic matter, pathogens and nutrients and not for also dealing with trace pollutants in general. Due to the highly variable physical and chemical properties of these organic compounds, the efficiencies by which they are removed may vary substantially.

Despite the low concentration levels at which pharmaceuticals are generally present in the environment, there is a significant potential for synergistic effects between compounds with similar modes of action or related therapeutic targets, which is enough to be of serious concern. Therefore, there is an urgent need to find ways of retaining and removing these pollutants before they reach the receiving water bodies. Optimization of the WWTP processes has been tried by increasing hydraulic and solid retention times, for example. In addition, some advanced technologies have been evaluated to decrease their discharge into water bodies. However, despite the sometimes high removal efficiencies attained, these processes are generally not cost-effective on a large scale. In fact, it remains a crucial necessity to find applicable technologies for removing pharmaceuticals from wastewater with higher efficiencies at reasonable cost of operation and maintenance.

Constructed wetlands systems (CWS) are being increasingly used as an option to remove micropollutants, in particular organic xenobiotic compounds, from wastewaters. There is a vast

range of studies highlighting the high efficiencies of these systems in removing a wide variety of compound types, including some pharmaceuticals. For this reason, this type of systems are being adopted as a tertiary treatment option in domestic wastewater treatment and, also, at least as part of the specialized wastewater treatment plants of some industries (such as chemical, dye, tannery, livestock, etc.).

Often CWS have been studied under a "black box" approach where only influent and effluent pollutants concentrations were assessed and no further in-depth investigations were pursued. However, in order to use CWS as a more efficient response to new challenges such as those presented by the more recalcitrant micropollutants, a thorough characterization of the processes involved in pollutants removal in CWS is direly needed, as well as some understanding of the ways the several CWS components (solid matrix, vegetation and microorganisms) may interact with each other synergistically. This, in fact, has been an effort which increasingly has been undertaken in the most recent years as a new trend in CWS research, not only in field studies but also in numerous lab studies as well. As result of the increases knowledge of such processes and interactions, a better guidance in the selection and optimization of the CWS components for more specific applications becomes possible.

In this work we intend to present a review of the main pharmaceutical removal and transformation processes in CWS, the roles played by the most important components of CWS in such processes and how the overall treatment system performance is affected by all these. Some attention will be given to the most recent studies published on this subject, especially those involving specific CWS application for the removal of pharmaceuticals and which focus on the characterization/optimization of processes or the selection of CWS components. Some of the questions remaining to be addressed about the removal mechanisms in CWS and the aspects of CWS operation that still require optimization will also be highlighted in this work.