Chapter 16
Bioremediation of Pharmaceutical Wastes

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ABSTRACT

The astounding increase in the use of pharmaceuticals in the last decade has raised concerns over their occurrence in the soils and wastewaters posing potential dangers to the general public health and environment. Considering the limitations of chemical remediation measures in treatment of recalcitrant xenobiotics, several bioremediation measures are being currently investigated and proposed for removal of pharmaceutical contaminants from the environment. Several bacterial, fungal and plant species have shown promising bioremediation potential with regard to the removal of pharmaceuticals. Varying configurations of anaerobic and aerobic reactors have been utilized for pharmaceutical wastewater treatment. This chapter is intended to give a compilation and overview of the various types of bioremediation measures currently being employed or investigated to remove the pharmaceutical pollutants.

INTRODUCTION

Pharmaceuticals comprise the broad group of synthetic as well as naturally obtained chemicals, intended for human or veterinary use as medicines. The use of pharmaceuticals and personal care products (PPCPs) has shown an astonishing increase in the last decade. Pharmaceutical industry production involves a wide range of raw materials, solvents, antibiotics, drugs and cosmetic products and hence, pharmaceutical effluents contain a wide variety of potentially harmful constituents (Dixit & Parmar, 2013). Pharmaceuticals enter the waste water, ground water, surface waters and soil through various means (Deziel, 2014). These include the sewage carrying excreta of patients on prescription or over the counter medicines, uncontrolled and unaccountable disposal of drugs by individuals as well as organizations, errant production houses lacking proper facilities for the disposal of drug waste, etc. The most frequently detected classes of pharmaceuticals in wastewater are NSAIDs, antibiotics, beta-blockers, lipid-regulators, steroids, antiepileptics, X-ray contrast media and tranquilizers (Drewes, 2007). The sewage treatment plants employed for treating wastewaters have been found to act upon the previously conjugated pharmaceutical residues (bound to a bile acid) excreted from the patients. The latter undergo

DOI: 10.4018/978-1-5225-2325-3.ch016

de-conjugation, yielding higher levels of free pharmaceutical substance in the plant outlet than in its incoming water. Wastewater reuse in areas with water scarcity leads to contamination of drinking water with pharmaceuticals like sulphamethoxazole, ibuprofen and carbamazepine in low levels (Luo, Guo, Ngo, Nghiem & Hai, 2014). Limited studies have shown that presence of these low level pharmaceutical contaminants in wastewaters can be potential dangers to human health (Pomati et al, 2006).

Further, the continual input of antibiotics into the environment is leading to emergence of newer antibiotic-resistant strains of microorganisms (Larsson, 2014). Currently, the antibiotic contamination is being recognized as a global environment issue. The recalcitrant nature of antibiotics sprouting from their inherent resistance to biodegradation due to their antimicrobial properties further complicates the issue in comparison with other classes of pharmaceuticals. This antibiotic contamination can promote the mobilization as well as the fixation of resistance genes among human and animal commensal bacteria along with other environmental and clinically-relevant species (Baquero, Tedim, & Coque, 2013; Kristiansson et al, 2011)). Several studies have shown the harmful effects of wastewater contamination on various animal species. Hormonal drugs have demonstrated capability of feminizing or masculinizing fish (Gilbert, 2012). Further, the non-steroidal anti-inflammatory drug (NSAID) diclofenac, can cause damage to the gills and lungs in fish populations (Gilbert, 2012).

The concerns regarding the presence of pharmaceuticals in the environment are many (Patneedi & Prasadu, 2015), and concrete remedial measures are yet to gain momentum but, this relatively recent field is rapidly acquiring eminence with several bioremediation measures being investigated and proposed for removal of pharmaceutical contaminants from the environment. Chemical methods can possibly lead to the generation of newer xenobiotics which can persist in the environment and may not be amenable to biological transformation. Biological processes utilizing microorganisms, plants and enzymes represent an eco-friendly approach towards the removal of pollutants from the environment. This book chapter is intended to explore and compile the various types of bioremediation approaches currently applicable (or holding considerable future promise) to successfully treat pharmaceutical industry effluents.

PHARMACEUTICAL WASTES AND THEIR ENVIRONMENTAL IMPACT

In recent times, concerns are being raised over the occurrence of pharmaceuticals in the environment and their potential adverse effects on general public health, flora and fauna and the aquatic environment. The pharmaceuticals may be categorized into four classes based on their occurrence in environment and their risk effects as:

1. Hormonal drugs and their derivatives, found in effluents at nanogram levels but pose a health risk due to their high potency and potential effects as endocrine disruptors,
2. Antineoplastics (anticancer) agents, with cytotoxic, carcinogenic, mutagenic and embryotoxic potential on account of their high reactivity,
3. Anti-infective agents, including antibiotics, and
4. Halogenated compounds such as X-ray contrast media, which are highly resistant to biodegradation and hence, highly persistent in the environment and food chain.

Several studies have highlighted the toxicity concerns of pharmaceuticals in wastewater, particularly, their potential to induce DNA damage and to cause lipid peroxidation effects (Mansour, Mosrati, Barillier,