Chapter 13
Occurrence and Treatment of Micropollutants in Landfill Leachate

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ABSTRACT

Micropollutants have emerged as a new challenge to the scientific community over the past decade. This chapter discusses the occurrence of various micropollutants in landfill leachate. Phthalic acid esters (PAEs) are one of the most investigated compounds in landfill leachate and are therefore given special focus in this chapter. The potential treatment options for these micropollutants are discussed with relevance to the estrogenicity potential of micropollutants. The potential of leaching of micropollutants from landfill sites is discussed to emphasize on the requirements of appropriate liners to avoid such exposure to the surrounding environment. Biological treatment in particular membrane bioreactors have been successfully used to remove some of the micropollutants. Advanced oxidation processes such Fenton and photo-Fenton have limited application reported in literature whereas other physic-chemical processes such as coagulation and adsorption have been demonstrated to be effective in the removal of micropollutants.

INTRODUCTION

Increasing population growth, changes in social and resource-use habits, and significant industrial and technological progress have led to an increase in the generation of municipal and industrial solid waste worldwide (Ojeda-Benítez & Beraud-Lozano, 2003; Renou et al., 2008). Landfills are one of the most affordable and acceptable means of final disposal of solid waste worldwide. Solid waste in a landfill is degraded by both aerobic and anaerobic processes. Once waste is placed in a landfill, it undergoes many physical, chemical and biological processes. These processes lead to production of landfill leachate and gas. Landfill leachate is a complex mixture with markedly varying composition depending largely on the type of waste and age of the landfill. Leachate production poses serious environmental concerns

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such as pollution of groundwater and surface water if not properly managed, collected and treated. These concerns are particularly serious, where waste is deposited in unlined landfills (Umar, 2010).

Landfill leachate is generally very high in organic matter (both biodegradable and refractory to biodegradation), with humic-like matter making up an important group, as well as ammonia–nitrogen, heavy metals, chlorinated organic and inorganic salts. Although much lower in concentration (μg/L to ng/L) when compared with conventional contaminates, micropollutants constitute an important group of contaminants in landfill leachate. Over the last few decades, there has been an increasing concern on their occurrence due the increasing concentration originating from a wide range of sources including pharmaceutical, chemical engineering and personal care product industries in rivers, lakes, soil and groundwater. Micropollutants are subjected to various processes such as distribution between different phases, biological and abiotic degradation in environment (La Farre et al., 2008). These processes contribute to their elimination and affect their bioavailability. The role of the aforementioned processes in micropollutants' fate depends on their physico-chemical properties (polarity, water solubility, vapor pressure) and the type of the environment (natural or mechanical), where the micropollutants are present (groundwater, surface water, sediment, wastewater treatment systems, landfill leachate, drinking water facilities) (Virkutyte et al., 2010). As a result, different transformation reactions can produce metabolites that often differ in their environmental behavior and ecotoxicological profile from the parent compounds. Micropollutants may include two classes of contaminants: (1) legacy contaminants of which toxic effects have been established, and control measures have been developed; (2) contaminants of emerging concern that are not currently regulated and are thought to have potential threats to environmental ecosystems or human health and safety (La Farre et al., 2008).

Persistence of micropollutants in the groundwater down gradient of landfills has been reported by in various studies (Barnes et al., 2008; Buszka et al., 2009). In fact, landfill leachate contaminated groundwater had been shown to have the highest median concentrations of micropollutants (Lapworth et al., 2012). As a result, landfills have been recognized as one of the primary sources of contamination in groundwater and surface water (Barnes et al., 2008; Befenati et al., 2003; Buszka et al., 2009; Holm et al., 1995; Stuart et al., 2012). Pharmaceutical and personal care products (PPPCs) and endocrine disrupting compounds are a great concern with regard to landfill leachate as these compounds have the potential to contaminate both surface and ground water. Because pharmaceuticals are biologically active substances designed to cure or prevent diseases, they can interfere with biological systems and their toxic effects can affect every hierarchical ecological level: subcell, cells, organs organisms, populations, ecosystems, and ecosphere (de Witte et al., 2011). Endocrine disrupting compounds disrupt the endocrine system of aquatic biota (multiple-appendaged amphibians, feminization of fish, etc.) (Yang et al., 2014). Recently, evidence from field research has indicated adverse reproductive and developmental effects in wildlife (Kidd et al., 2007).

Treatment of landfill leachate is therefore, an important part of leachate management strategy. Several physicochemical and biological techniques are used for the treatment of landfill leachate, such as coagulation, flotation, chemical precipitation, adsorption, membrane filtration and various biological processes (i.e., sequencing batch reactors, anaerobic sludge blanket) (Garcia-Lopez et al., 2014; Ince et al., 2010). A combination of physicochemical and biological processes is generally needed to treat landfill leachate to an acceptable level. Conventional treatment approaches can be ineffective for the treatment of micropollutants. As a result, there is an increasing interest in alternative novel approaches that are efficient in removing such toxic compounds and to remove potential estrogenicity. A combination of conventional and novel processes is in particularly, promising considering the increasingly stringent