Chapter 11
Treatment of Landfill Leachate by Anammox Process

Grzegorz Cema
Silesian University of Technology, Poland

Adam Sochacki
Silesian University of Technology, Poland & Czech University of Life Sciences, Czech Republic

ABSTRACT

In most cases, the anammox process is used for nitrogen removal from reject water coming from dewatering of digested sludge. However, there are more industrial streams suitable for treatment by partial nitritation/anammox process. The landfill leachate may be a good example of such wastewater. Generally, landfilling is the most used solution for treatment of urban solid wastes. The problem with landfill leachate production and management is one of the most important issues associated with the sanitary landfills. These streams are highly contaminated wastewater with a complex mixture of organic and inorganic compounds and characterized by a high ammonia content and low biodegradable organic fraction matter. The objective of this chapter is the short characteristic of landfill leachate and a short review of its treatment methods with special focus on nitrogen removal by partial nitritation/anammox process.

INTRODUCTION

In Europe, the total amount of landfilled municipal waste has been diminishing, due to European Commission Council Directive (Council Directive 1999/31/EC). Nevertheless, landfilling of the municipal waste is still a common practice in the waste management system in some European countries and the rest of the world because it is the simplest and cheapest method of waste disposal. Even discontinuation of landfilling in the EU will not instantaneously eliminate the problem related to landfill leachates because even closed and capped landfills will produce these wastewater streams. Such waste management option has several negative impacts on the environment. The major potential environmental impact related to landfill leachate generation is pollution of groundwater and surface water (Kjeldsen et al., 2002). The problem with landfill leachate production and management is one of the most important issues associated with the sanitary landfills. These streams are highly contaminated wastewater with a complex mixture of organic and inorganic compounds and are characterized by high ammonia concentrations and low

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biodegradable organic fraction matter content. High loads of refractory compounds, the low value of BOD_5 (five days Biochemical Oxygen Demand) to COD (Chemical Oxygen Demand) ratio and high concentration of nitrogen cause that this kind of wastewater is complicated and expensive for treatment, as well as requires various processes to be effective (Kaczorek & Ledakowicz, 2006). The changes in waste management caused by the EU directives resulted in reduced volume of leachate produced per tonne of waste landfilled and thus increased leachate strength (Brennan et al., 2015).

Both physical/chemical methods and the biological process can be used to treat landfill leachates. In spite of stable treatment effects, and preferable adaptability to the changes of wastewater quantity and quality, physical/chemical methods have several shortcomings: odors, air pollution, high chemical costs and high energy consumption. The main reason for the selection of a biological process for nitrogen removal is the lower cost compared to the physicochemical methods. Conventional biological nitrogen removal with the use of nitrification/denitrification is probably the most efficient process to eliminate nitrogen from leachate; however, the biodegradable carbon to nitrogen ratio necessitates the use of external carbon source for complete denitrification. Additionally, the nitrification process requires high energy input for aeration. For these reasons, it was important to obtain technology that facilitates enhanced nitrogen removal under the conditions of low carbon availability and with low energy requirements for nitrification. During the last two decades, the possibility of treatment of highly loaded streams with low C to N ratio by partial nitritation and the anammox process has been tested and demonstrated. However, up to now, there are still very few studies reporting the use of anammox process to treat landfill leachate.

CHARACTERISTICS OF LANDFILL LEACHATE

Landfill leachate is generated by the rainwater infiltrating through the landfill site, the surface and groundwaters flowing into the site as well as water present in the wastes and generated as a result of organic matter degradation. The quality and the quantity of leachate is mainly related to: chemical and physical properties of waste, volumes of infiltrating water, environmental conditions, the landfill age and also storage and reclamation techniques (Christensen et al., 2001; Kulikowska & Klimiuk 2008; Müller et al., 2015).

Generally, the discharge from landfill depends on rainfall, evaporation losses and redistribution in time of infiltrating water in the soil cover and in the waste deposited. The water infiltrating into the site may be transpired to the atmosphere, evaporated from the surface soil, stored in cover soil or percolate downwards through the cover (Peyton & Schroeder 1993; Bengtsson et al., 1994). The water balance on the landfill site can be summarized as follows (Blakey, 1992):

$$L = P - R - \Delta U_s - ET - \Delta U_W \quad (1)$$

Where:L – leachate production, P – precipitation, R – surface run-off, ΔUs – change in soil moisture storage, ET – actual evaporative losses from the bare-soil/evapotranspiration losses from a vegetated surface, ΔUw – change in moisture content of the refuse components.

Leachate is known as wastewater whose treatment is very complicated and expensive as its composition is variable from different landfills and, moreover, its composition is changing with the landfill age. For this reason, the treatment methods have not been unified so far (Kaczorek & Ledakowicz 2006; Kulinowska & Klimiuk 2008). The components present in the leachate usually have different origins. However, four main groups of compounds may be distinguished (Alkalay et al., 1998; Christensen et al.,

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