Potential and limits of landfill leachate treatment in a multi-stage subsurface flow constructed wetland – evaluation of organics and nitrogen removal

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Abstract
Constructed wetlands have potential of treating wastewater of poor biodegradability. The performance of a multistage sub-surface flow wetland treating municipal landfill leachate was assessed during three years of operation. During the study three research periods with different operation conditions were established. The hydralic loads, operation mode of vertical flow beds and type of treated wastewater (raw leachate – leachate mixed with municipal wastewater) were changed. Removal of organic matter and nitrogen species was evaluated in each period. The average COD removal efficiency varied from 47.8% to 86.6%. The average total nitrogen removal efficiencies were 98.5%, 68.9% and 79.6% in subsequent research periods. The main problem was too high concentration of recalcitrant organic matter. The labile organic matter was completely removed however the effluent COD remained on relatively high level. Depletion of labile organic matter also limited denitrification resulting in incomplete total nitrogen removal.

Keywords
constructed wetlands systems, biodegradability, humic substances, ammonium

1. Introduction

Landfill leachates (LL) are created while rainwater percolates through the landfilled wastes, washing out by-products of organic matter (OM) degradation and substances deposited at the landfill. Qualitative and quantitative characteristics of LL is changing with age of a landfill, type of lanfilled wastes, lanfilling methods (i.e. method of compaction, recirculation of LL) and climatic conditions (rainfall depth, intensity, time distribution, air temperature etc.). Generally, LL contain very high concentrations of OM and Kjeldahl nitrogen TKN (the sum of ammonium and organic nitrogen) (Robinson, 2007; Klimiuk et al., 2007). Basing on literature review, Christensen et al. (2001) reported that ammonium concentrations in LL can vary from 50 to 2200 mg/l. Also low share of biodegradable OM expressed in BOD_5 in the total OM concentration is characteristic of the LL (Christensen, 2001; Calace et al., 2001; Paxeus, 2008). OM concentrations as well as OM biodegradability depend on the stage of OM degradation which varies with the age of a landfill. Three phases of OM degradation can be distinguished, starting with aerobic degradation, followed by anaerobic phase and ending up with humic phase (Bozkurt et al., 2000).The aerobic organic waste degradation produces large amounts of carbon dioxide and water and runs until the available oxygen is depleted, which is a relatively short process (1-3 months). Recently, the concept of aerobic landfills with air injections is growing in popularity. Introducing air to the waste tip encourages aerobic transformation of wastes which is expected to increase the degradation rate, enhance ammonium nitrogen removal and shorten the waste stabilization period (Berge et al., 2005; El Fadel et al., 2013). In conventional anaerobic landfills, when oxygen is consumed, the anaerobic degradation phase proceeds, when nitrates, sulphates and ferric and manganese oxides are used as electron donors. This phase is sub-divided into acidic and methanogenic phase. In the acidic phase the labile organic compounds (i.e. cellulose) are degraded and volatile fatty acids (VFA) and carbon dioxide are formed leading to the increase of BOD