Comparison of several combined/integrated biological-AOPs setups for the treatment of municipal landfill leachate: Minimization of operating costs and effluent toxicity

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Abstract

The treatment of medium-age landfill leachate was investigated by employing several set-ups including a sequencing batch biofilter granular reactor (SBBGR) step, with or without ozone enhancement, followed or not by a polishing stage with solar photo-Fenton (SpHF). Objectives of the investigation were to compare different treatment strategies in order to achieve the lowest operating cost and to reduce the toxicity of the final effluent, evaluated by three different tests (respirometry, Vibrio fischeri and Lepidium sativum phytotoxicity). These objectives were addressed for two different target COD values, namely 160 and 500 mg/L, to be met in the final effluent for disposing of to water bodies and to sewers, respectively, requested by Italian environmental regulation. The different treatment strategies have demonstrated to be technically suitable for achieving the requested COD (160 or 500 mg/L) and reduction of the initial toxicity goals. For the COD target of 500 mg/L, the investigated treatment set-ups proposed in this paper showed to have comparable operating cost (3.2 €/m³). Instead, when the target COD is 160 mg/L, the combination SBBGR + SpHF is economically more convenient (4.1 €/m³) being the operating cost of the other two investigated treatment set-ups (SBBGR/O3 and SBBGR/O3 + SpHF) 5.7 and 4.8 €/m³ respectively. As far as toxicity reduction is concerned, for both the COD target of 500 and 160 mg/L, the SBBGR/O3 set-up gave better results than other investigated treatment options.

1. Introduction

Sanitary landfilling is currently the most widely used method throughout the world for municipal solid waste (MSW) disposal [1]. Up to 95% total MSW collected worldwide is disposed of in landfill [2] and in 2007 a total of 102 million tons of MSW were disposed of to landfill in the European Union [3]. Unfortunately, municipal landfill leachates, resulting from the percolation of water through solid waste, are considered one of the types of wastewater with the greatest environmental impact. The composition of the landfill leachates varies depending on the nature of the wastes disposed of, on soil characteristics, rainfall patterns and on the "age" of the landfill [4,5]. Leachate contains substantial amounts of dissolved organics (BOD and COD), xenobiotic organic compound, inorganic salts, ammonia, heavy metals and other toxicants [6,7]. More than 200 organic compounds have been identified in municipal landfill leachate [8,9] with upwards of 35 of them having the potential to cause threat to the environment and human health [8,10]. Usually, "young landfill leachates", containing high amounts of volatile fatty acids (i.e., a high BOD/COD ratio), are easier to be treated than "old and medium-age leachates", since the latter contains a fraction of organic compounds escalantir to biological treatments. Such refractory compounds are dominated by humic-like and fulvic acid-like organics that consequently lead to a reduction of BOD/COD ratio [11]. It follows that stabilized landfill leachates compared to young ones are more difficult to treat for several reasons. First, the potential toxic effect due to high levels of ammonia makes the conventional nitrification–denitrification biological process not very suitable for removing ammonia from old leachates unless very long hydraulic residence times are adopted. Moreover, the high salinity and lack of sufficient electron donors, featured of stabilized leachates, are additional obstacles to nitrification–denitrification biological treatment. Second, the significant presence of recalcitrant pollutants in old leachates makes difficult to meet the COD discharge limit since these compounds pass unaltered through the biological stage of the treatment plant. Conventional biological