

# Effect of PAC addition in combined treatment of landfill leachate and domestic wastewater in semi-continuously fed batch and continuous-flow reactors

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## Abstract

The combined biological treatability of landfill leachate and domestic wastewater was investigated in both semi-continuously fed batch (SCFB) and continuous-flow (CF) activated sludges with recycle. Powdered activated carbon (PAC) was added in order to investigate the improvement in organic carbon removal and nitrification. The results obtained in SCFB and CF operations were compared to each other. In both types of operations, COD and ammonia removal efficiencies decreased with an increase in the leachate ratio of the total wastewater. As the leachate ratio increased, the positive effect of PAC on COD removal and nitrification became more apparent. In SCFB-type operations, nitrification was more inhibited than in CF operations. Additionally, the enhancement of nitrification was more apparent in CF operations than in SCFB operations where there was PAC addition. In CF operations, sufficient PAC addition could completely prevent nitrification inhibition and nitrite accumulation was avoided. With regard to nitrification, the positive impact of PAC was observed after some time since inhibition of nitrifiers was more severe than heterotrophs.

## Nomenclature

BOD <sub>5</sub>	5-day biochemical oxygen demand (mg·l <sup>-1</sup> )
CF	continuous-flow reactor
COD	chemical oxygen demand (mg·l <sup>-1</sup> )
TCOD	total COD
SCOD	soluble COD
MLCOD	mixed liquor COD
NO <sub>x</sub> -N	nitrite and nitrate nitrogen (mg NO <sub>2</sub> -N+NO <sub>3</sub> -N·l <sup>-1</sup> )
MLSS	mixed liquor suspended solid (mg·l <sup>-1</sup> )
MLVSS	mixed liquor volatile suspended solids (mg·l <sup>-1</sup> )
OUR	oxygen uptake rate (mg·l <sup>-1</sup> ·h <sup>-1</sup> )
PAC	powdered activated carbon
PACT	powdered activated carbon treatment
SCFB	semi-continuously fed batch reactor
TKN	total Kjeldahl nitrogen (mg·l <sup>-1</sup> )

## Introduction

Sanitary landfill leachate is usually a very high strength wastewater containing many organic and inorganic constituents. Due to the high strength of leachate, care should be given in combined treatment of leachate and domestic wastewater in an activated sludge system. A previous study on combined landfill leachate and domestic wastewater treatment demonstrated that these could be treated at suitable mixing ratios (Çeçen and Çakiroglu, 2001). However, in that study leachates were shown to contain non-biodegradable matter which could not be removed by biological treatment alone. Also an increase in leachate ratio caused a reduction in the overall organic substrate removal rate in batch reactors. In addition to this, a severe nitrification inhibition may be observed in high-strength leachates due to the high free ammonia levels and

presence of other inhibitors. Activated carbon addition in the form of PAC is known for its ability to enhance biological treatment efficiency, remove refractory organic compounds and to enhance nitrification. Therefore, PAC addition to activated sludge could also be tested in leachate treatment systems (U.S. EPA, 1995; Kang et al., 1990).

Organic matter removal in a PACT system is a combination of adsorption and biodegradation. Activated carbon in conjunction with activated sludge increases the removal efficiency by adsorbing non-biodegradable, toxic and/or inhibitory organics and also some metals. Many researchers have suggested that a synergy exists between activated carbon and micro-organisms. Thus, the PACT system could remove an organic compound more efficiently than would be expected from either biodegradation or adsorption alone. The mechanism consists of the stimulation of biological activity by bioregeneration of PAC. Activated carbon provides an attachment surface for micro-organisms and protects them from shock loadings of toxic and inhibitory materials, whereas micro-organisms bioregenerate the activated carbon (Sublette et al., 1982, Marquez and Costa, 1996; Kim et al., 1997; Jonge et al., 1996; Orhansky and Narkis, 1997).

Many studies in literature also showed that nitrification was enhanced by the addition of PAC to activated sludge (Ng et al., 1987, Ng and Stenstrom, 1987; Specchia and Gianetto, 1984). The most probable reason was the removal of toxic and inhibitory organics and inorganics by PAC (Ng et al., 1987, Ng and Stenstrom, 1987). The majority of studies deal with nitrification enhancement in industrial wastewater treatment and there is a lack of information on nitrification in landfill leachate treatment in the case of PAC addition.

The objective of this study was the investigation of PAC addition in combined biological treatment of sanitary landfill leachate and domestic wastewater. In another study (Aktas and Çeçen, 2001), adsorption isotherms were shown and the effect of PAC in batch reactors was discussed in detail. On the other hand, this study addressed the impact of PAC under steady operating

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