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Use of an algal consortium of five algae in the treatment of landfill leachate using the high-rate algal pond system

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Abstract Five species of microalgae *Chlorella vulgaris*, *Scenedesmus quadricauda*, *Euglena gracilis*, *Ankistrodesmus convolutus* and *Chlorococcum oviforme*, were screened for their ability to grow in treated landfill leachate (TL) using shake flask cultures. The treated leachate had undergone previous treatment through mechanical aeration in treatment ponds at the landfill site. The five algae, except for *C. oviforme*, were able to grow in medium containing up to 50% TL. Two high-rate algal ponds (HRAP) equipped with paddlewheel were used for the semi-continuous cultures. A mixture of the five algae was used to inoculate one of two HRAPs for secondary treatment of TL. The other HRAP was filled with natural lake water containing mixed populations of algae. A volume of 400 mL (1%) from both ponds were removed daily and replaced with TL. The leachate loading rate was increased to 2% (0.8 L day^{-1}) on day 197 and then to 4% (1.6 L day^{-1}) on day 309, providing hydraulic retention time of 100, 50 and 25 days, respectively. Although higher biomass was obtained in the HRAP containing the consortium of five algae, there was no significant difference in reduction of pollutants between the two ponds. The HRAPs produced algal biomass ranging from 2.00 to 5.54 g dry weight L^{-1} with significant reduction in chemical oxygen demand (91.0%), ammoniacal nitrogen (99.9%) and orthophosphate (86.0%) contents. The HRAP offers a potential treatment system for TL which is simple, low cost, flexible in use and requiring low maintenance.

Keywords Microalgae · Landfill leachate · High-rate algal pond (HRAP) · Bioremediation

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Introduction

A landfill is a natural biological reactor used to treat and allow final disposal of municipal wastes. Much research has focused on the chemical and microbiological aspects of landfilled wastes, particularly the production of highly contaminated aqueous leachate and landfill gases (Kim et al. 2006). Leachate is a strongly contaminated liquid that accumulates beneath the landfill site as a result of infiltration processes. Leachate contains dissolved chemicals including liquid produced from both natural degradation as well as compression of the waste and rain water. In a municipal waste landfill, methane, carbon dioxide, ammonia and hydrogen sulphide are generated due to anaerobic decomposition of the waste (Reinhart and Townsend 1998). Leachate could be highly toxic, with high concentrations of organic and metal compounds, as well as pathogens, which can pollute both surface as well as groundwater (Read et al. 2001). Leachate has to be treated before discharge into water bodies, to avoid impact on aquatic life and water quality (Renou et al. 2008). Landfill leachate is complex, its quality depends on many factors including flow rate, age of the landfill, precipitation and other seasonal weather variations as well as the type of wastes.

One of the most common practices of leachate treatment consists of recycling the leachate back into landfill which improves its quality when provided with suitable recirculation rates and volumes. Chemical and physical methods,

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