Treatment of a high-strength leachate from a closed co-disposal landfill site in South Africa

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Abstract

A high-strength leachate from a closed co-disposal landfill site was characterised to determine its chemical composition and susceptibility to biological treatment. The leachate required dilution to 25% (v/v) before it responded to aerobic catabolism. Complete anaerobic treatment was ineffective even with a final dilution of 90% (v/v) of the original leachate. Indirect inhibition of methanogenesis by the high sulphate concentration was the probable cause. Following phosphate addition, aerobic biological treatment effected a significant chemical oxygen demand (COD) reduction but did not lower the ammoniacal-N concentration. Scaling and precipitation occurred which did not adversely affect the biological process but could cause operational problems in full-scale leachate treatment plants. Ion exchange, with soil and lime addition, was, therefore, considered to effect inorganic content reductions prior to biological treatment.

Introduction

Landfill leachate, which originates from water which has percolated through emplaced refuse, is a complex and highly polluting waste water which contains organic and inorganic materials and suspended solids (Ho et al., 1974; Chian and DeWalle, 1976). If leachate is allowed to enter groundwater it can have serious environmental impacts. Protection of groundwater is of particular concern in South Africa. At present, most leachate produced by South African landfill sites is either discharged to sewer or disposed to land. Unfortunately, these practices are often uncontrolled. Treatment of landfill leachate may, therefore, be necessary to minimise the pollution potential.

Complete characterisation of a leachate is a pre-requisite for determining a suitable treatment. Such analysis provides information of the microbiological processes operative within the landfill and identifies the microbiocidal components which may limit biological treatment, or which cannot be discharged to sewer (Chu et al., 1994).

Landfill leachate can be treated *in situ*, by recirculation back through the refuse mass, or can be collected and treated externally by biological and physico-chemical methods. Biological treatment (aerobic and anaerobic), which is generally considered to be reliable, simple and cost-effective, is suitable for leachates which contain high concentrations of volatile fatty acids (VFAs). Reductions of >90% in COD (Chian and DeWalle, 1976; Robinson et al., 1982; Robinson and Maris, 1985) and BOD (Boyle and Ham, 1974) have been observed in laboratory studies. Knox (1985) and Robinson and Luo (1991) also demonstrated ammonia removal through nitrification during aerobic treatment. Physico-chemical treatment is ineffective for leachates with high organic contents but is beneficial for treating leachates from stabilised landfill sites, and for further "polishing" initially high-strength leachates following biological treatment (Chian and DeWalle, 1976). For a leachate with a high inorganic content, physico-chemical treatment, prior to subsequent biological treatment, minimises the possible effects of metal toxicity, corrosion and scaling (Scott, 1982). The efficacies of chemicals to remove colour, turbidity, heavy metals, calcium and magnesium have been well documented (Thornton and Blanc, 1973; Chian and DeWalle, 1976; Farooq and Velioglu, 1989; Swiderska-Bróz, 1991; Sletten et al., 1995). Each of these does, however, carry attendant costs.

The principal objective of this study was to determine a suitable, cost-effective treatment protocol for a high-strength leachate from a closed co-disposal landfill site.

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Materials and methods

Landfill leachate

Collected leachate from a closed co-disposal site in Gauteng was stored in 20l closed containers at 4°C until required. The site had been operated for 17 years before accepting domestic refuse only until the full capacity was reached. The range of products (8.1% w/w of the total waste) co-disposed at the site included pesticides, pharmaceutical and veterinary compounds, medical wastes, food processing wastes and phenolic wastes.

Phosphate supplement

For some aerobic studies KH_2PO_4 (0.38 $g.l^{-1}$) and K_2HPO_4 (0.13 $g.l^{-1}$) were added (1, Table 1).

Medium

The basic mineral salts medium described by Coutts et al. (1987) was used in the anaerobic studies (2, Table 1)

Batch cultures

Table 1 summarises the experimental details for the initial batch cultures. The leachate was diluted with glass-distilled water and the inoculum (15% w/v) was one-month-old refuse. For the aerobic cultures, 250 *ml* conical flasks, plugged with non-absorbent cotton wool, were used and were incubated (30°C) in