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Anaerobic/aerobic treatment of municipal landfill leachate in sequential two-stage up-flow anaerobic sludge blanket reactor (UASB)/completely stirred tank reactor (CSTR) systems

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Abstract

The treatability of leachate produced from the lab-scale simulated reactor treating food wastes was investigated in a two-stage sequential up-flow anaerobic sludge blanket reactor (UASB)/aerobic completely stirred tank reactor (CSTR). Experiments were performed in two UASB reactors and a CSTR reactor having effective volumes of 2.5 and 9 l, respectively. The hydraulic retention times in anaerobic and aerobic stages were 1.25 and 4.5 days, respectively, through 42 days at a constant flow rate of 21. After the start-up period, the COD concentration of leachate was steadily increased from 5400 to 20,000 mg/l. OLRs were increased from 4.3 to 16 kg/m^3 per day by increasing the COD concentrations from 5400 to 20,000 mg/l. The effluent of the first anaerobic UASB reactor (Run1) was used as the influent of the second UASB reactor (Run2), while the effluent of the second UASB reactor was used as the influent of the aerobic CSTR reactor (Run3). COD removal efficiencies of the first UASB reactor and in the whole system (two steps UASB + CSTR) were 58, 62, 65, 72, 74, 79% and 96, 96.8, 97.3, 98, 98 and 98%, respectively. As the OLR increased from 4.3 to 16 kg/m^3 per day, the COD removal efficiency reached a maximum of 80%. NH_4-N removal efficiency was approximately 99.6% after the aerobic stage. The maximum methane percentages of the first and second UASB reactors were 64 and 43%, respectively.

Keywords: Leachate treatment; Sequential anaerobic/aerobic system; COD removal; NH_4-N removal; Volatile fatty acids; Methane gas

1. Introduction

Solid waste landfills may cause severe environmental impacts if leachate and gas emissions are not controlled. Leachate generated in municipal landfill contains large amounts of organic and inorganic contaminants [1]. Leachate may also have a high concentration of metals and contain some hazardous organic chemicals. The removal of organic material based on COD, BOD and ammonium from leachate is the usual prerequisite before discharging the leachates into natural waters [2]. Anaerobic treatment methods are more suitable for the treatment of concentrated leachate streams, offer lower operating costs, the production of usable biogas product and production of a pathogen-free solids residue which can be used as cover material [2–4]. High-rate anaerobic processes such as up-flow anaerobic sludge blanket reactor (UASB) and anaerobic filter have been shown to be efficient in the treatment of leachate having a COD higher than 800 mg/l and the BOD/COD ratio higher than 0.3 [1].

İnanç et al. [5] used three different reactors (an UASB reactor, an anaerobic up-flow filter and a hybrid bed reactor) for the anaerobic treatment of leachate. Organic loading was increased gradually from 1.3 to 8.2 kg COD/m^3 per day at a hydraulic retention time varied between 2.4 and 2 days. All the reactors showed similar performances against organic loadings with COD removal efficiencies of 80 and 90%. Kettunen and Rintala [1] showed that leachate can be treated on-site UASB reactor at low temperature. A pilot-scale UASB reactor was used to study treatment of municipal landfill leachate (COD 1.5–3.2 g/l) at 13–23 °C. COD (65–75%) and BOD_7 (up to 95%) removals were achieved at organic loading rates (OLR) of 2–4 kg COD/m^3

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per day. Similarly, in a study carried out by Kettunen et al. [2], it was observed that anaerobic and sequential anaerobic–aerobic treatment of leachate is possible at low temperatures. The sequential process produced effluent quality (COD < 380 mg/l, BOD < 22 mg/l) close to the requirements for municipal wastewater treatment plants. Shin et al. [6] conducted a study to investigate the performance of the UASB reactor treating leachate from the acidogenic fermenter in the two-phase anaerobic digestion of food waste. The COD removal efficiency was consistently over 96% up to the loading rates of 15.8 g COD/l per day, while the methane production rate was 5.5 l per day.

The main source of nitrogen is proteins, which accounts for approximately 0.5% of dry weight of municipal solid waste released to the leachate [7]. Different process configurations and operation models have been reported for the removal of organic and nitrogen removal from landfill leachates. Im et al. [4] used an anaerobic–aerobic system including simultaneous methanogenesis and denitrification for the treatment of leachate using an up-flow anaerobic biofilm reactor, an aerobic-activated sludge reactor and a clarifier. Ilies and Mavinic [8] also used a four-stage Bardenpho process for biological nitrification and denitrification of a high ammonia landfill leachate. The study realised by Jokela et al. [7] showed that nitrogen can be removed effectively from landfill leachate using a nitrifying up-flow biofilter with waste material as a filter medium combined with subsequent denitrification of the nitrified leachate in the landfill body. Kennedy and Lentz [9] investigated the treatment of the municipal landfill leachate using sequencing batch and continuous flow UASB reactors. Performances of the reactors were very similar at low and intermediate OLRs. It was found that the continuous UASB reactors are more favourably than the sequencing batch UASB system at higher OLRs [9].

Lin et al. [10] examined the operating parameters and treatment efficiency in digestion of septage with landfill leachate by using four lab-scale anaerobic CSTR digesters. Septage and leachate were mixed at the ratio of 1:0, 1:1, 2:1 and 3:1 on the basis of COD. For each digester, the sludge retention time (SRT) were controlled at 20, 10 and 5.3 days. For the same SRT, a higher ratio of septage increased the removal efficiencies of COD, ammonia nitrogen and total phosphorus. The methane yield increased with an increasing septage fraction. Hoilijoki et al. [11] investigated nitrification of anaerobically pre-treated municipal landfill leachate in lab-scale activated sludge reactor. Aerobic post-treatment produced effluent with 150–500 mg/l COD, less than 7 mg/l BOD and on an average, less than 13 mg/l NH_4-N.

The objective of this study was to determine the treatment of the leachate produced from the organic fraction of municipal solid waste (food) in sequential two-staged

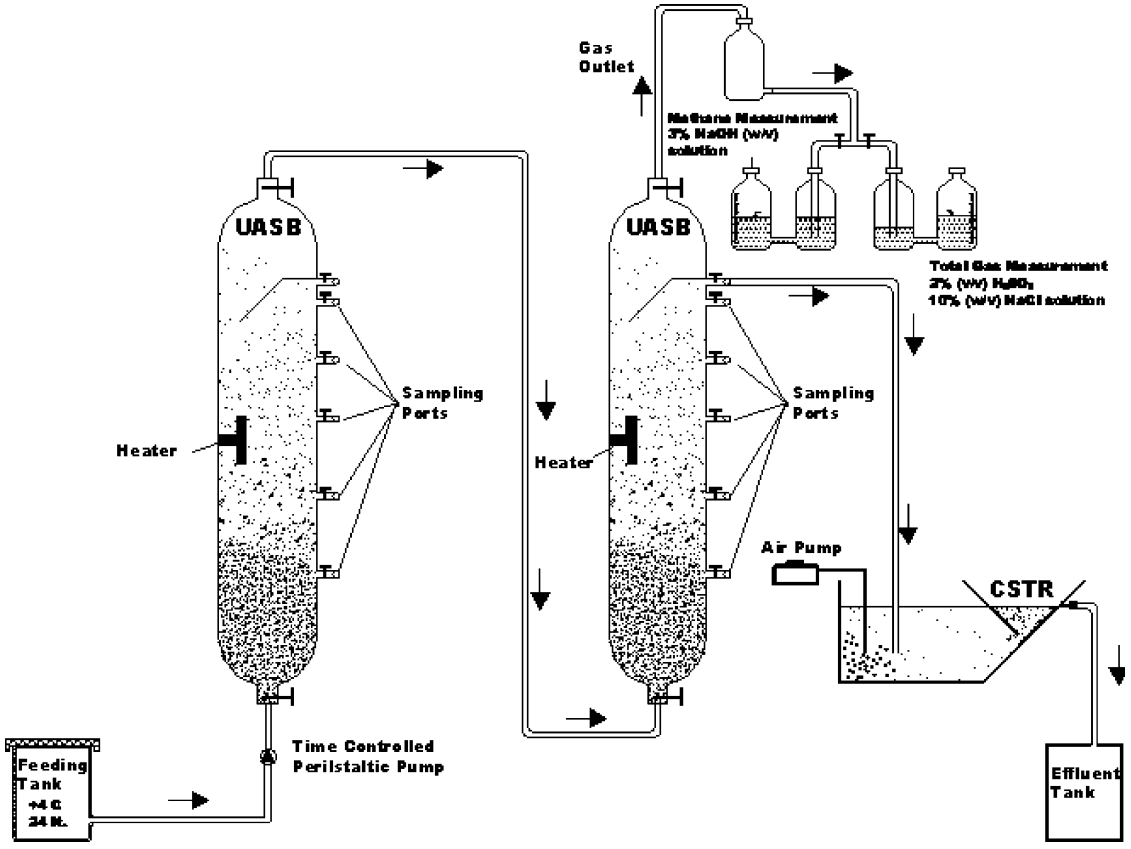

Fig. 1. Schematic configuration of lab-scale anaerobic/aerobic sequential reactor system.