Effect of recirculation rate on anaerobic treatment of fleshing using UASB reactor with recovery of energy

E Ravindranath¹*, Chitra Kalyanaraman¹, S Shamshath Begum¹ and A Navaneetha Gopalakrishnan²
¹Department of Environmental Technology, Central Leather Research Institute (CLRI), Adyar, Chennai, 600 020, India
²Centre for Environmental Studies, Anna University, Guindy, Chennai 600 025, India

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This study presents performance of upflow anaerobic sludge blanket (UASB) reactor in treating liquefied fleshings (LFs) with tannery wastewater (TWW) using liquefaction reactor (LR). With increase in recirculation rate, methane production increased in LR than in UASB reactor due to methanogenic bacteria in LR. UASB reactor with continuous feeding of LFs and TWW resulted with cumulative methane in UASB reactor (128 l) and LR (145 l).

Keywords: Biomethanation, Fleshing disposal, Liquefaction, Tannery wastewater treatment, UASB

Introduction

Usually processed wastewater from leather processing is collected for further treatment in either common effluent treatment plants (CETP) or effluent treatment plants (ETP) before discharging into water bodies. Unutilized fleshing is dumped in lower-lying regions and riverbanks. Aerobic treatment of organic matter emits volatile compounds (ketones, aldehydes and ammonia)¹². Hence, anaerobic digestion is the best option with production of biogas, reduced green house gases and pollution control¹³. Studies are reported on high strength organic wastes (slaughterhouse waste⁴-⁶, food waste⁷-⁹, beverage¹⁰ and pulp and paper¹¹,¹² etc.). Liquefaction of fleshings¹³ has been carried out under anaerobic conditions in batches.

This study presents performance of upflow anaerobic sludge blanket (UASB) reactor in treating liquefied fleshings (LFs) with tannery wastewater (TWW) using liquefaction reactor (LR). Effect of recirculation rates and subsequent methane generation was studied.

Experimental Section

Solid and Liquid Samples

TWW and solid wastes (wet limed fleshings) (Table 1) were collected from Talco Vaniyambai Tanners Enviro Control Systems Ltd, India.

Liquefaction Reactor (LR)

Initially LR was filled with UASB reactor effluent. Wet fleshing (150 g) was introduced into LR daily through perforation provided at the top of reactor. Part of effluent from UASB reactor was circulated through LR to facilitate liquefaction of fleshing. LFs were recirculated through UASB reactor. Various recirculation rates studied were 3.0 l/day, 3.2 l/day, 6.5 l/day, 10.6 l/day and 11 l/day.

UASB Reactor

Composite TWW (4 l) was fed into UASB reactor daily. Along with TWW, LFs from LR was also introduced into UASB reactor. Inoculum [total solids (TS), 54 g/l and volatile solids (VS), 27 g/l] for UASB reactor was obtained from pilot plant (capacity, 12.5 m³) (CLRI, Chennai, India) to treat domestic wastewater.

Analytical Methods

Chemical oxygen demand total [COD (T)], TS, VS, alkalinity, sulfate, sulfide and chloride of samples in UASB reactor and LR were measured by standard methods. Volatile fatty acid (VFA) concentration was measured as acetic acid equivalent using a standard distillation method. Samples (50-100 ml) were withdrawn from the top of UASB reactor and LR, pH of influent / effluent of UASB reactor and LR were measured daily by portable pH meter (pH 330, WTW - Germany).
Methane Production

Methane gas produced was passed through soda lime pellets column (length, 0.22 m; diam, 0.03 m) and was measured by wet flow gas meter. Soda lime pellets were changed regularly after entire column turned to blue from pink.

Experimental Set up

A bench scale system consisting of glass UASB reactor and LR was fabricated. Entire process was carried out at ambient temperature (30 ± 1°C). LFs (150 g) were added daily in LR and were introduced by peristaltic pumps in UASB reactor. Controlled recirculation was maintained between UASB reactor and LR.

Results and Discussion

COD and VFA Concentrations in UASB Reactor Influent, Effluent and LR

Average COD (T) of UASB reactor’s influent and effluent and that of LR were found to be 1767 mg/l, 1296 mg/l and 3005 mg/l respectively. In LR, COD (T) concentration decreased with increase in recirculation rate from 3.2 l/day (3783 mg/l), to 6.5 l/day (2314 mg/l), 10.6 l/day (2146 mg/l) and 11 l/day (1767 mg/l) due to dilution and immediate conversion of digested COD to methane. In anaerobic conditions, acidogenic bacteria convert organic matter to VFA. Influent (TWW), effluent and LR’s average VFA were found to be 749 mg/l, 336 mg/l and 1508 mg/l respectively (Fig. 1).
Average VFA of UASB reactor's influent was found to be 42% of average influent COD. Initially VFA in LR was more than 2226 mg/l when recirculation rate was 3 l/day and decreased to 846 mg/l when recirculation rate was 11 l/day. VFA (45%) was converted into methane in LR when recirculation rate increased from 6.5 l/day to 11 l/day. VFA /alkalinity ratio shows stability, well-buffered condition of an anaerobic system. In present study, value of VFA /alkalinity ratio (< 0.4) illustrates stability of UASB reactor.

Treated effluent from UASB reactor was continuously recirculated into LR as a source of microbial consortia to liquefy fleshings. LFs were pumped into the bottom of UASB reactor along with TWW. Recirculation of UASB reactor effluent into LR and production of VFA in LR resulted in reduction of pH. Initially, pH value in LR was > 9 and decreased to an average of 7.4 at the end of study. Most of the studies have proved that pH of 6.5 - 7.5 is most suitable for methanogenesis\textsuperscript{14}, pH of UASB influent and effluent were 7.0-7.7 and 7.2-8.0 respectively. Influent and effluent pH values of UASB reactor show favorable condition for methanogenesis.

Recirculation Rate on Methane production in UASB Reactor and LR

During start up, recirculation rate was maintained at 3 l/day and later it was maintained in increasing order (3.2 l/day, 6.5 l/day, 10.6 l/day and 11 l/day) to assess investigation on effect of recirculation rate on methane production. Corresponding average methane production with respect to above mentioned recirculation rate in LR was found to be 0.12 l, 0.59 l, 1.7 l, 2.6 l and 3.3 l. Thus methane production in LR was increasing with increase in recirculation rate due to more microbes (fermentative, acidogenic and acetogenic) were provided in LR. This reflected in consumption of more VFA in LR and was converted into methane in LR itself.

On the other hand, incase of UASB reactor, corresponding average methane production was found to be 2.2 l, 1.94 l, 1.46 l, 1.12 l and 0.9 l. It was observed that with increase in recirculation rate, methane production was decreased. VFA, which are responsible for methane production, supplied to UASB reactor in form of LFs was decreased through recirculation in UASB reactor and hence decrease in methane production was observed. Cumulative methane production (Fig. 2) in LR was higher than that in UASB reactor. Methanogens were promulgated in LR through recirculation from UASB reactor. With increase in recirculation rate from 6.5 l/day to 11 l/day, methane production in LR was increased. Totally, 128 l and 145 l of methane were produced in UASB reactor and LR respectively.

Conclusions

This study shows feasibility of liquefaction of fleshing using UASB reactor and LR. With increase in recirculation rate from 3 l/day to 11 l/day, methane pro-
duction in LR was found to be increased than UASB reactor. Wet limed fleshing generated in tanneries can be treated successfully using this system.

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References