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Combined Treatment of Real Sugar Industry and Sago Wastewater Using Hybrid Upflow Anaerobic Sludge Blanket (HUASB) Reactor

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ABSTRACT

This paper presents the performance of Hybrid Upflow Anaerobic Sludge Blanket (HUASB) reactor in treating combined real sugar industry and synthetic sago effluents. Sugar industry is one of the most important agricultural industries which discharge the effluent in a huge quantity that creates environmental problems. The disposal of untreated sugar industry effluent in soils and water bodies has received much attention since decades ago. So, in this study, it was decided to inoculate the HUASB reactor with seed sludge from the existing anaerobic digester treating sago wastewater and then it was started by using synthetic sago wastewater, and then it was fed with the combined real sugar industry and synthetic sago wastewater. The reactor was fed with the combined effluents of a real sugar industry and synthetic sago wastewater at different mixing ratios having the Chemical Oxygen Demand (COD) ranging from 4450 to 5360 mg/L with HRT of 24 hours. The pH, COD removal, volatile fatty acid (VFA), alkalinity and biogas production were monitored for various inlet of COD values. The inlet and outlet pH was between the range of 5.62 to 7.36 and 7.53 to 8.18 respectively. The VFA and alkalinity varied from 36 to 84 mg/L and 926 to 998 mg/L respectively. The biogas production varied from 10.6 to 13.2 L/d. The maximum COD removal of 94.4% and the biogas production of 13.2 L/d was reported at pH 8.11 at the mixing ratio of 60/40 (sago/sugar industry wastewater).

INTRODUCTION

Sago is a main agro-based product found in various parts of the world. Products from tapioca like starch and sago introduced in India since1940s onwards. Processing of tapioca need 20,000-30,000 L of water per ton of sago; besides it produces same quantity of wastewater which is extremely organic, foul smelling and acidic. Most of the starch units generate effluent within the range of 200-300 m^3/d. Several studies reported that the sago industry wastewater may bring about drastic ecological imbalances in the nearby agro ecosystems if it is not treated properly (Murthy & Patel 1961, Saroja & Sastry 1972, Gnanapragasam et al. 2010, Senthilkumar et al. 2011).

Sugar industry contributes to the development of the economy in many countries, but arguably harms the environment (Ndobeni et al. 2019). The conversion of natural habitats for cane cultivation in coastal areas and tropical islands has led to critical environmental damage, loss of biodiversity and ecosystem services at landscape levels (Rein et al. 2011). These wastes not only represent a threat to the environmental quality but also possess a potential energy value which is not fully utilized despite the fact that they are cheap and abundant in most parts of the world (Hampannavar & Shivayogimath 2010).

Anaerobic treatment converts the wastewater organic pollutants into small amount of sludge and large amount of biogas as source of energy (Ayati & Ganjidoust 2006). Whereas aerobic treatment needs external input of energy for aeration. The upflow anaerobic sludge blanket (UASB) reactor is by far the most widely used high rate anaerobic treatment system for variety of wastewater (van Haandel & Lettinga 1994). The anaerobic biological sludge blanket systems proposed over recent years have elicited considerable interest because of their good removal efficiencies of organic substrates, their relatively simple layout and the low capital and operating costs. Granular biomass with high methanogenic activity and excellent settling properties can be cultivated in these reactors (Buzzini et al. 2006).

The investigation is on the feasibility of treatment of real sugar industry effluent under bench scale hybrid upflow anaerobic sludge blanket reactor of stressed loadings. Shortening the start-up time bears practical significance as it can raise attractiveness of HUASB reactor applications by saving time and cost. After the start-up process the reactor were operated at various mixing ratio of real sugar industry and synthetic sago wastewater and COD, pH, VFA, alkalinity and biogas were monitored regularly.

MATERIALS AND METHODS

Biomass

In the present research, materials were collected from sago factory which is located in Salem. The unspecified microoraganims present in the granular sludge from the starch effulent were used in the study. The sludge was completely washed before loading and filtered in a mesh in order to minimize the inorganic components present in the granules. About 60000mg/L content of sludge was estimated as volatile suspended solids (APHA 2005).

Wastewater

Sugar industry: Real sugar industry wastewater was collected from M.R.Krishnamurthy Co–operative sugar mill Ltd, Sethiyathope village, Chidambaram Taluk, Cuddalore District, Tamil Nadu, India. The characteristics were immediately analysed before feeding the reactor.

Synthetic sago: In this research synthetic sago wasterwater was prepared in which nitrogen and phosphorus were added along with starch and minerals in the ratio of 5:1:550. Ferric chloride, zinc sulphate, copper sulphate present as nutrients were added to the reactor at the concentration of 1.0ml/L (Bhatti 1995, Arshad et al. 2009).

Experimental Setup

In this research study benchscale HUASB reactor was designed and fabricated using perspex tube (Fig 1). The reactor of about 20L volume has a total height of 1.42m with 1.17m as the effective height and 0.15m diameter. The upper most part of the reactor has solid-gas-liquid separater (GLSS) portion which is mainly for biogas collection in the form of inverted conical funnel. The gas produced from the reactor can be estimated by water displacement method. A peristaltic pump (20 ppm) was used to pump the substrate into the reactor with constant discharge flow. Bioballs as support media were used in this study and placed in top segment in the reactor. Totally 152 bioballs were kept in the reactor to prevent the escape of biogranules from the reactor. Five sampling ports at different heights were installed for ease of collection of samples for analysis. The reactor was operated at 30±3°C.

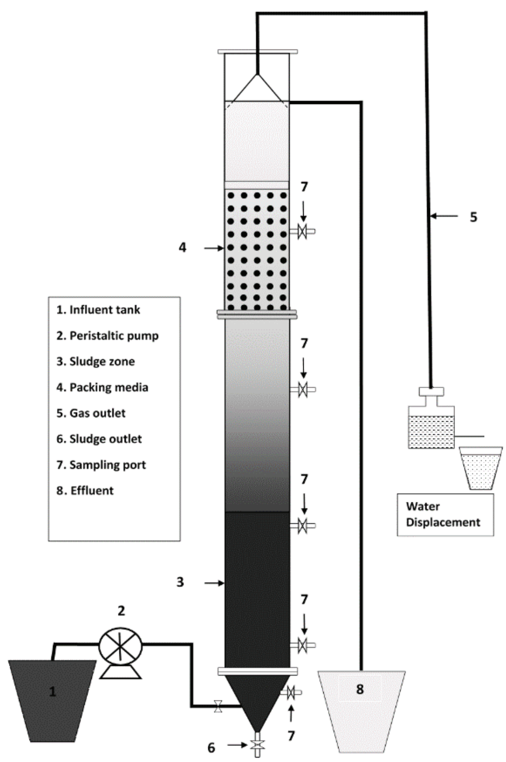

Fig. 1: Schematic representation of Bench Scale Hybrid Anaerobic Slude Blanket Reactor.

RESULTS AND DISCUSSION

COD Conversion and Removal Performance

After mixing the wastewater of sago and sugar industries, the COD values of influent and reactor outlet are presented in Fig. 2. The COD values range from 5360 to 4450 mg/L. The COD removal efficiency for different effluent mixing proportions at 24 h HRT is presented in Fig. 3.

The COD removal efficiency was in the range of 61.9-94.4 %. At effluent mixing ratio of 60/40 (sago 60 %, sugar 40 %), the overall COD removal efficiency was 94.4 %.

pH, VFA and Alkalinity

The pH values of the inlet and outlet of HUASB reactor are presented in Fig. 4. The HUASB reactor effluent pH increased to a value beyond 7 and always remained so (range 7.53-8.18). The VFA values in HUASB reactor were in the range of 36-84 mg/L (Fig. 5) and VFA value increased when the sugar industry effluent proportion was increased. The HUASB reactor effluent alkalinity was in the range of 926-998 mg/L (Fig. 6).

VFA/Alkalinity Ratio

The Fig. 7 shows VFA/Alkalinity ratio (VFA/AL) in the HUASB reactor. The effluent of HUASB reactor had VFA/AL ratio less than 0.089. It means that process in HUASB reactor is under stable condition.

Senthilkumar et al. (2009) reported that the VFA/Alk ratio for acidogenic and H UASB reactors is in the range of 1.3-1.5 and 0.04-0.09. A stable anaerobic treatment system requires a balance among all microorganisms. The maintenance of this balance is normally indicated by a low VFA concentra-

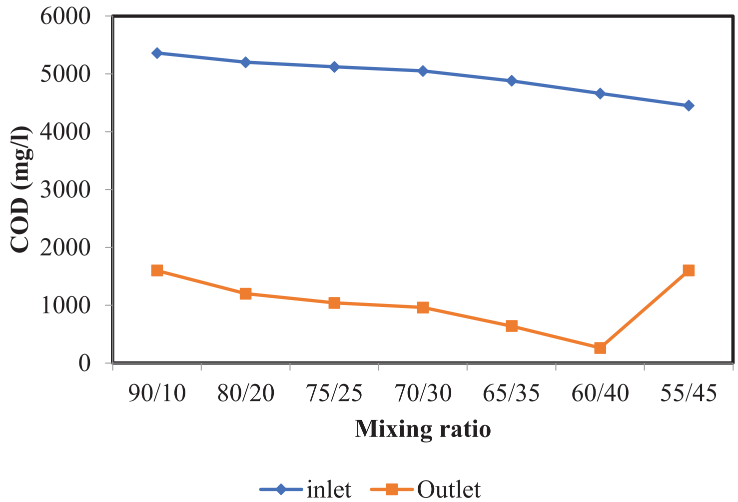

Fig. 2: COD values at various mixing ratios.

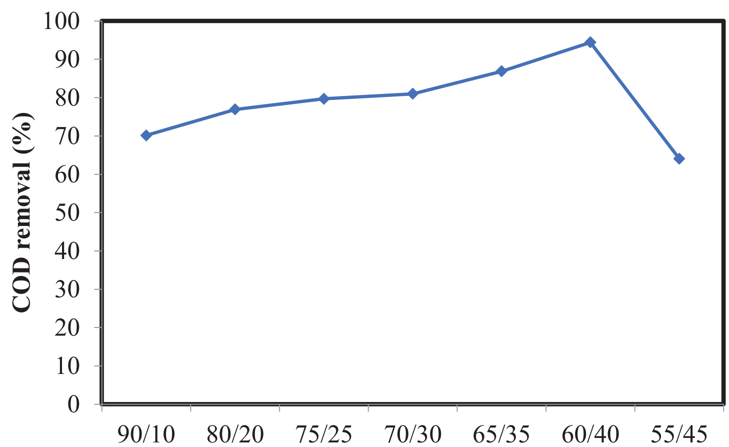

Fig. 3: COD removal efficiency at various mixing ratios.

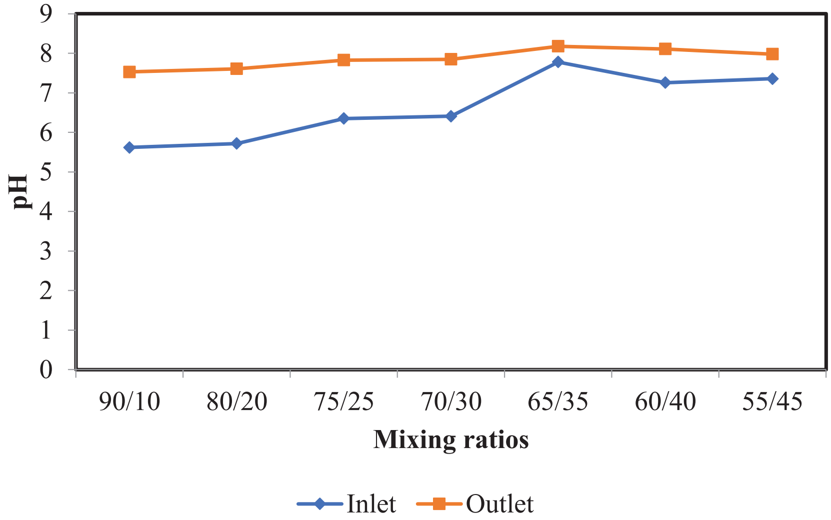

Fig. 4: pH values at various mixing ratios.

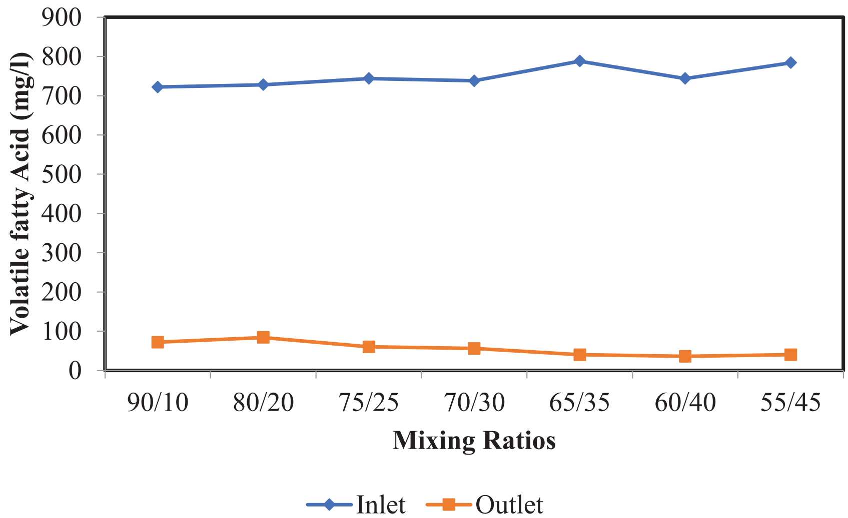

Fig. 5: VFA concentration at various mixing ratios.

tion, appropriate pH and VFA/Alk ratio. If a UASB reactor is stable, the VFA/Alk ratio of the reactor effluent must be lower than 0.4 (Behling et al. 1997). Sanchez et al. (2005) stated that the optimum ratio of VFA to alkalinity should be less than 0.3 or 0.4 for UASB reactor.

Biogas Production

Fig. 8 shows the biogas production at various mixing ratios such as 90/10, 80/20, 75/25, 70/30, 65/35, 60/40 and 55/45 for HUASB reactor. The maximum biogas production of 13.2 L/d was achieved at the mixing ratio of 60/40.

CONCLUSION

The bench-scale hybrid upflow anaerobic sludge blanket (HUASB) reactor was used to treat combined effluents of the real sugar industry and synthetic sago wastewaters. The maximum COD removal of 94.4% and the biogas production of 13.2 L/d at pH 8.11 was found at the mixing ratio of 60/40 (sago/sugar industry wastewater). The pH, VFA and alkalinity of the reactor effluent were under control for every 24 h of HRT which indicates the stability of the reactor. From the results obtained it was clear that HUASB reactor could be a very feasible alternative, eco-friendly and sustainable treatment system for the combined real sugar industry and sago wastewater.

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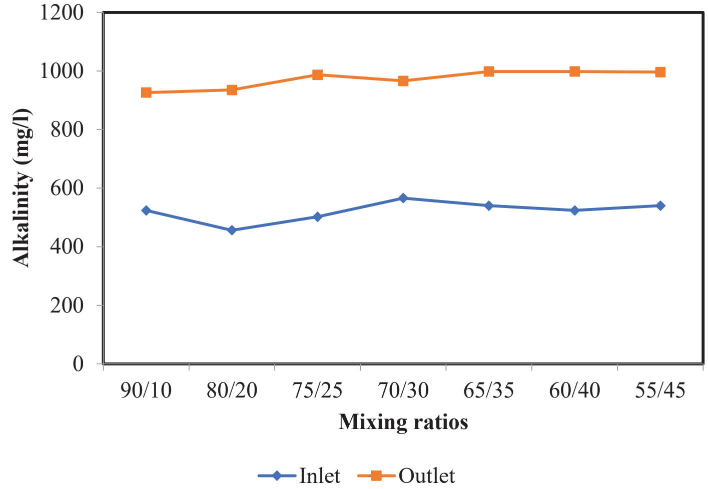

Fig. 6: Alkalinity at various mixing ratios.

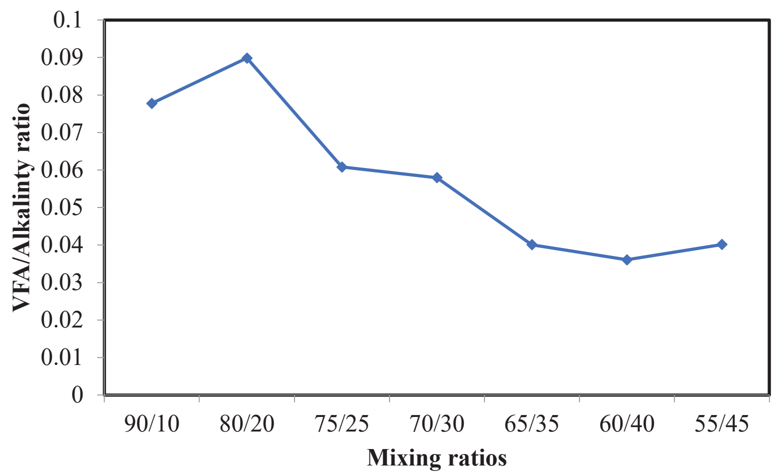

Fig. 7: VFA/Alkalinity at various mixing ratios.

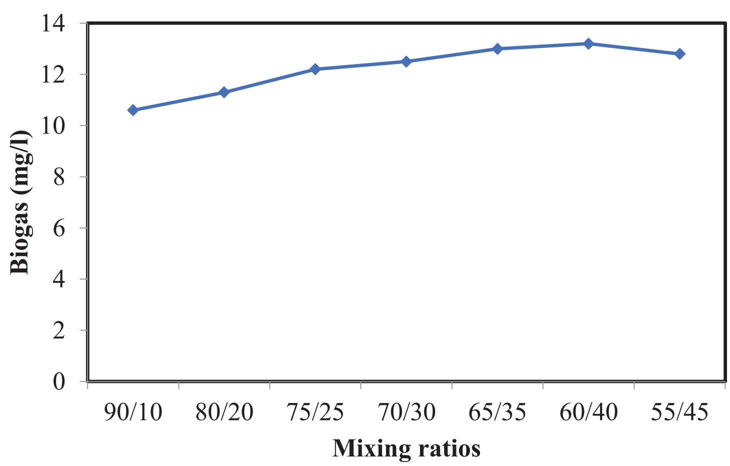

Fig. 8: Biogas production at various mixing ratios.

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