Evaluation of biogas production for different operating parameters in UASB reactor treating combined textile dying and sago industry effluent

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Abstract:

Biogas is an important renewable energy resources which can be produced from from combined textile dyeing and sago industrial effluent treatment using Upflow Anaerobic Sludge Blanket (UASB) reactor under various operating conditions. The textile dyeing and sago industry waste water were procured from Tara dyers and Perumal sago factory respectively. In this, 230 litters capacity of UASB reactor was used to treat the combined wastewater by varying the operating parameters such as mixing ratio, recycle of effluent ratio, hydraulic retention time (HRT), temperature and total dissolved solids (TDS). The reactor was started up using sago wastewater and biogas production was monitored. Initially the reactor was started with only sago wastewater and then the operating parameters were varied. As a result the maximum production of biogas obtained was during startup is 126 l/d, at different mixing ratio is 6 l/d, at different recycle ratio 355 l/d, at various HRT is 504 l/d, at different temperature is 512 l/d and at various TDS is 490 l/d.

Key words: biogas, anaerobic, upflow, textile dyeing, sago

1. Introduction

Environmental pollution is one of the biggest problems the world faces today. It may be defined as the deterioration in the chemical, physical and biological properties of our surrounding and are classified into three major types based on the occurrence, that is, air, water and soil pollution. Water is the foremost and vital for life on earth. It is an essential natural resource for ecological sustenance, agricultural productivity, environmental purity, industrial growth, power production and enrichment and renewal of land and air. Water has been a cheaper commodity for a long period, but has never been accounted for its processing cost. Now it has become scarce and priced commodity for its treatment to make it suitable for domestic, industrial use and irrigation.

Due to industrialization, environmental pollution has been recognized as one of the major problems of the nation. Human activities in the industrially advanced countries during the last few decades have surpassed nature as agent of change in the global environment. In recent years, different approaches have been discussed to tackle man made environmental hazards. Clean technology, eco-mark and green chemistry are some of the most highlighted practices in preventing and/or reducing the adverse effect on our surroundings. The treatment and reclamation may be further justified in view of growing concern over the contamination of water resources by the release of more recalcitrant compounds and diminishing water resources. Conventional waste management technologies, commonly adopted in tropical climates, are not only expensive but also warrant exacting operation and maintenance requirements.

The wastewater discharge from textile industry contains various pollutants such as degradable organics, colour, nutrients, pH altering agents, salts, sulfur, toxicants and refractory organics (Somasiri *et al*., 2008; Haroun and Idris, 2009). Strong colour is one of the most notorious characteristics of textile mill effluents. It is difficult to remove colour from the effluents by conventional physico-chemical treatment systems, biological treatment may be the best alternative as the operational costs are relatively low compared to conventional technologies (Gnanapragasam *et al*., 2010, 2011). The traditional aerobic wastewater treatment systems do not substantially decrease the colouration of these wastewaters, while a number of research reports demonstrated the effectiveness of anaerobic decolourisation (Isik andSponza, 2005; Sandhya *et al*., 2008). In addition, dyestuff can be used as sole carbon source by microorganisms in some cases along with co-substrate as carbon source (Chang *et al*., 2001). A co-substrate is defined as the carbon and energy source for microbial growth, maintenance and release of the electrons for cleavage of dyes under reducing environment (Sponzaand Isik, 2004). Tapioca starch producing industrial wastewater was used as co-substrate in this study. As tapioca starch wastewater is highly organic, foul smelling and acidic (Banu *et al*., 2006), discharge of it will lead to depletion of dissolved oxygen in the imported water sources. Moreover, tapioca starch wastewater causes air pollution by stringent foul odour, inorganic carbon deposit and change of soil matrix in the lands. So the wastewater from both the industries was mixed together and biogas obtained may be utilized for domestic purpose.

2. Materials and Methods

2.1 Biomass

The methanogenic granular sludge with unknown microorganisms used in this experiment was procured from the anaerobic digester treating tapioca starch effluent of M/s Perumal SAGO factory, Salem, Tamilnadu, India. Before loading the reactor, granular sludge was clearly washed, filtered through a fine mesh to reduce all the inorganic mineral contents. The volatile suspended solids content of the sludge was then estimated about 60000 mg/l (APHA 2005).

2.2 Wastewater

The real untreated wastewater of starch industry and textile dye industry was collected from Perumal Sago factory and Tara textile dyeing industry, Salem, Tamilnadu, India. Totally ten wastewater samples were collected from each industries for duration of three months and the mean values of the parameters have been tabulated in Table 1. The complete analysis of the wastewater was carried out according to standard methods APHA 2005.

Table 1 Characteristics of wastewaters

S.No.	Parameters*	Textile dye effluent	Sago Effluent
1	pH	12.8	4.5
2	Total Suspended Solids	420	640
3	Total Dissolved Solids	3520	1200
4	Chlorides	1520	400
5	Sulphates	180	123
6	BOD	175	2400
7	COD	1600	6000

*All values except pH are mg/l

2.3 Experimental Setup

In order to study the operational and performance characteristics of UASB reactor, a hybrid bi-phasic Upflow Anaerobic Sludge Blanket (UASB) reactor was fabricated (Fig. 1). The acidogenic and methanogenic reactors are fabricated with 1:4 volumetric ratios. The first phase is an acidogenic reactor (300 mm inner diameter and 820 mm height) was made up of plexi-glass with working volume of 56 l and second phase is a stainless steel methanogenic reactor (350 mm inner diameter and 2400 mm height) with working volume of 230 l. First the untreated real effluent was fed into the acidogenic reactor and secondly from acidogenic to the methanogenic reactor. Sampling ports were provided at various heights of reactor approximately 400 mm. On the top of the reactor, gas deflection was attached. The Gas-Liquid-Solid (GLSS) separator consisted of an inverted conical funnel at top of the water column for the collection of biogas. In addition to the GLSS arrangement, a packed medium consisting of a PVC spirals size of 26 mm, surface area 500 m^2 m^{-3} and void ratio 87% has been provided a height of 200 mm locating at 1770 from the bottom of the reactor. The spiral will retain the biomass in addition to giving polishing effect to the effluent. The sludge granules trapped in GLSS and the spiral will return to the reactor as soon as the gas entrapped inside the granules is released. Biogas generated was measured using wet gas flow meter.

4. Result and Discussion

4.1 Biogas production during startup of the reactor

The Figure 2 shows the biogas production during the start-up period of pilot-scale UASB reactor. It is clear that the biogas production for the first 20 days is low (16 to 76 L/d). After 21st day of the start-up the biogas production shows an increasing trend and reaches 126 L/d (0.36 m^3/kg COD) on the 30th day with methane content of 58%. Kaparaju *et al*. (2009) reported the maximum biogas of 0.219 m^3/kg COD using pilot-plant UASB reactor treating wheat straw hydrolysate.

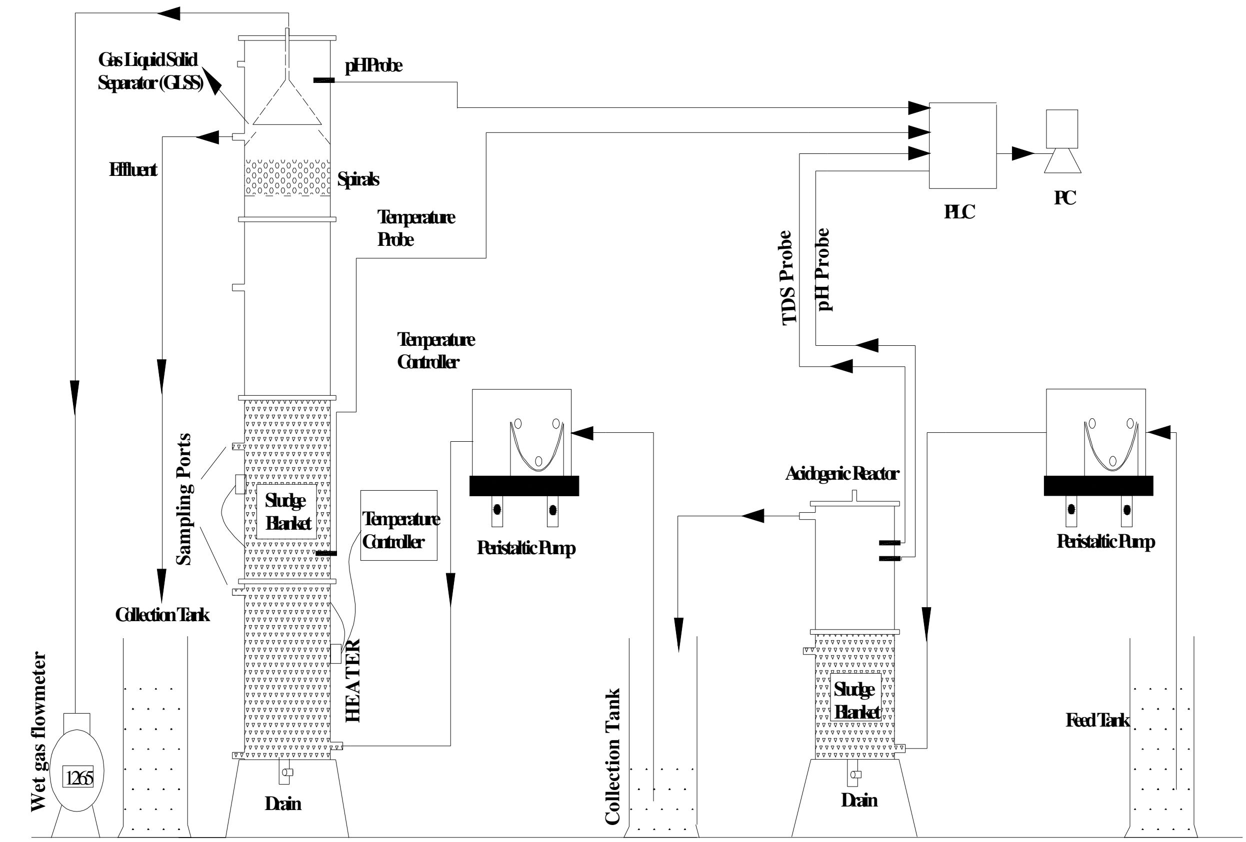

Figure 1: Schematic representation of pilot scale two phase UASB reactor experimental setup

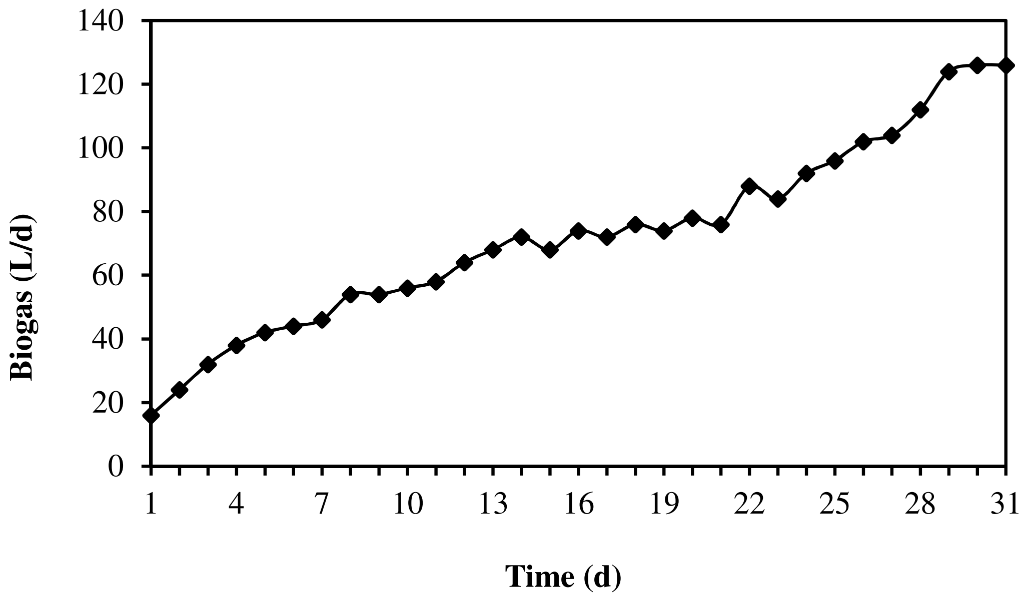

Figure 2: Biogas production during startup period in pilot-scale reactor

4.2 Biogas production at various mixing ratio

The biogas generation is directly related to type of substrate given as feed to the reactor. The Figure 3 point out the biogas production at different mixing ratios under optimum recycle ratio. The maximum biogas production of 512 L/d with methane content of 42 % was attained at 70:30 mixing ratio. The biogas production for other mixing ratios 65:35, 60:40, 55:45, 50/50 and 45:55 were 456, 439, 386, 356 and 328 L/d respectively. The COD stabilization in reactor is directly related to biogas evolution, which decreases the COD of outlet wastewater from the reactor and provides the mechanisms for stabilization of the biodegradable organic matter. Talarposhti *et al.* (2001) achieved a maximum biogas production of 16 L/d on treating simulated textile dyeing wastewater using two-phase anaerobic packed bed reactor with working volume of 15 L

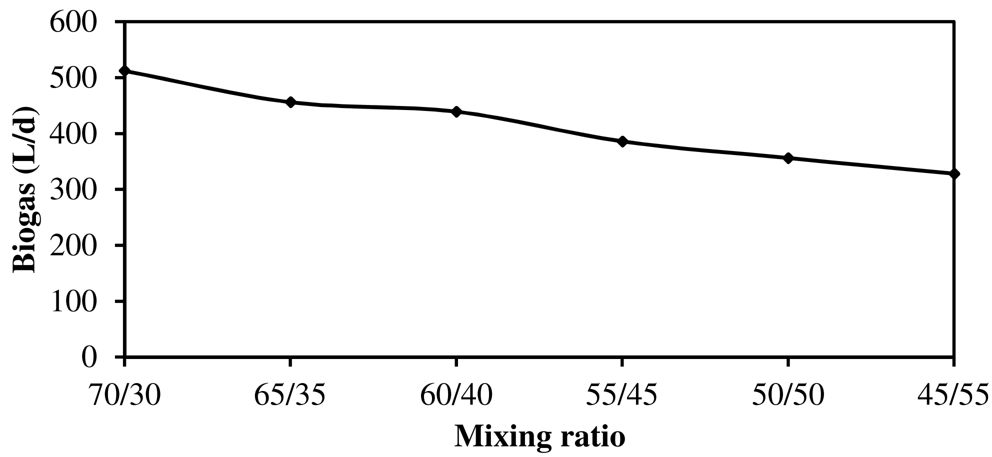

Figure 3: Biogas production at different mixing ratios

4.3 Production of biogas under various recycle ratio

The biogas production at various percentage of effluent recycles at 24 h HRT was shown in Figure 4. The biogas generation was decreased with increase of dye wastewater. The maximum production of biogas was measured about 355 L/d for 30% effluent recycle, whereas, the biogas production at 10, 20, and 40% was recorded as 158, 284 and 324 L/d, respectively. As the recycle ratio increases the biogas production was increased. Isik (2004) reported the maximum biogas production of 180 ml/day when the COD was 2,026 mg/L treating textile dyeing wastewater.

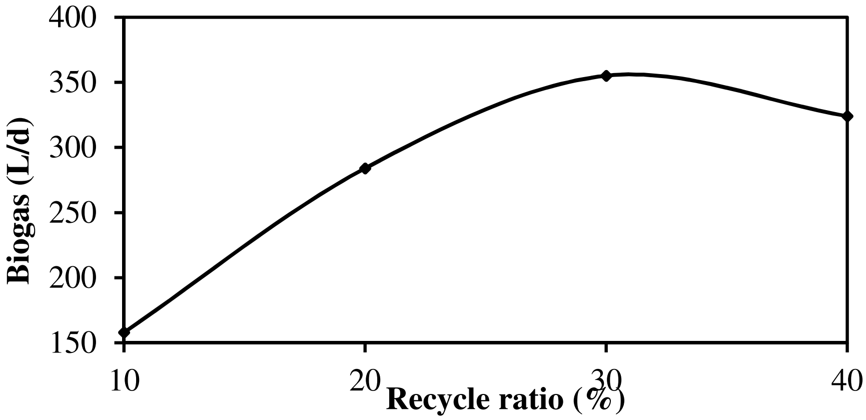

Figure 4: Biogas production at different recycle ratios

4.4 Biogas production at various HRT

Biogas production at different HRTs *viz*. 36, 30, 24 and 18 h for methanogenic reactor was 345, 456, 488 and 502 L/d, respectively is shown in Figure 5.The maximum biogas production of 504 L/d was achieved at 18 h of HRT. It is evident from the Figure 5 as the HRT decreases the biogas production increases. Minimal COD removal occurs without biogas production and it is associated with the formation and release of H_2 (Grady *et al*. 1999). Silva *et al.* (1999) reported that the biogas production rate was influenced significantly by the HRT decrease, in opposite of the COD removal that decreased.

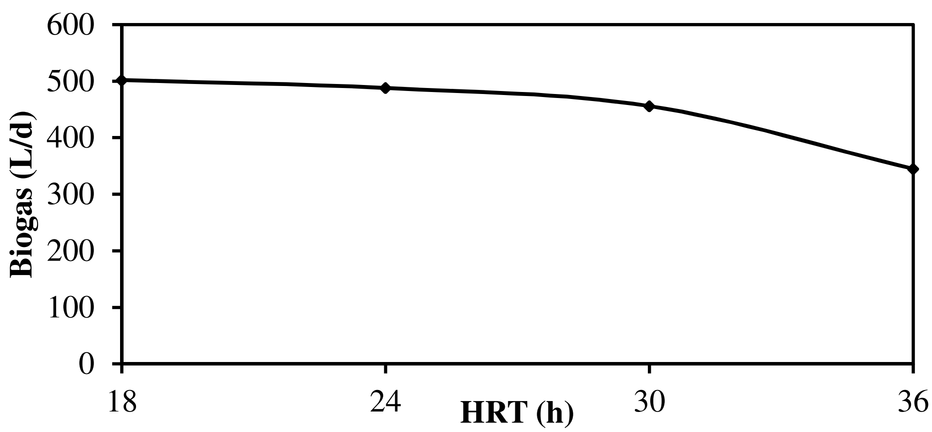

Figure 5: Biogas production at various HRTs

4.5 Biogas production at various temperatures:

The Figure 6 shows the biogas production at different temperatures 35, 40, 45 and 50^{0}C of methanogenic reactor. The maximum biogas production of 512 L/d was achieved at 45^{0}C in methanogenic reactor. The biogas production increases to 386, 456, 512 L/d as the temperature increases at 35, 40, 45^{0}C respectively. Kavimani *et al.*, 2020 have treated sago effluent and obtained 22 l/d of biogas.

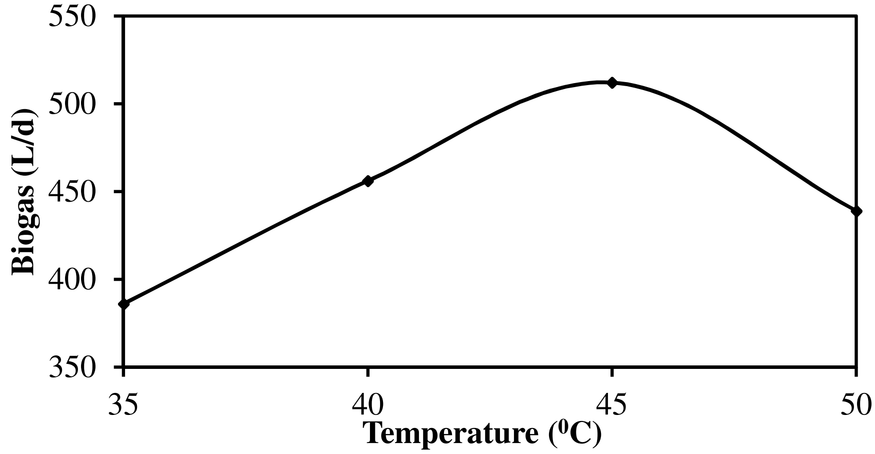

Figure 6: Biogas production at different temperature

4.6 Effect of TDS on Biogas production

The biogas production at various TDS concentration at 24 h HRT is shown in Figure 7. The biogas generation decreased with increase in TDS concentration. The maximum production of biogas was measured about 490 L/d for a TDS of 10000 mg/L, whereas the biogas production at 12000, 14000 and 16000 mg/L was recorded as 488, 456 and 438 L/d respectively. Biogas production is directly related to COD stabilization. Isik (2004) reported the methane production of 1.8 L/d when the salt concentration was 32 mg/L treating simulated textile dye wastewater using UASB reactor with effective volume of 2.5 L.

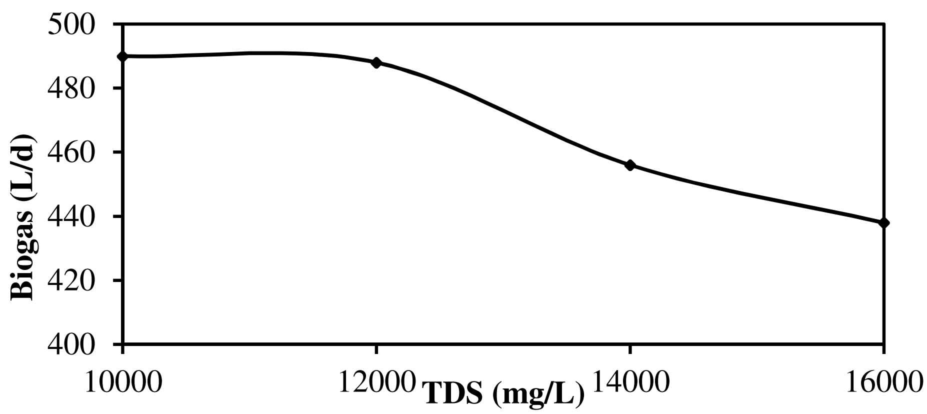

Figure 7: Biogas production at various TDS

5. Conclusion

In this study we have identified that the biogas production at various mixing ratio of textile dyeing and sago wastewater under recycling options with various operating parameters. The various operating parameters such as HRTs, temperatures and TDS at optimum mixing and recycle ratio. The maximum biogas production was 512 l/d at maximum temperature of 45ºC with mixing ratio of 70 % of sago wastewater and 30% of textile dyeing wastewater. From this result it came to know that the anaerobic microorganism are active and degrades the waste material effectively.

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