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Start-up of Hybrid Upflow Anaerobic Sludge Blanket Reactor with Organic Wastewater

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Abstract*: *In the process of treating wastewaters from different industries by using anaerobic reactor, initially the start-up process is the first step to stabilize the reactor. The aim of this research is to conduct the start-up process and to evaluate the characterization of synthetic organic wastewater using Hybrid up flow Anaerobic Sludge Blanket reactor (HUASBR) with the effective volume of 20L. Initially the reactor was processed with synthetic organic wastewater with COD of 3200 mg/l. The processes were continuously operated with hydraulic retention time of 24 hours for 48 days. The results obtained after the process of stabilization were, COD removal is 87.8%, VFA was Stable for the operating condition, Biogas production was increased as 13.2 l/d during the maximum removal of COD and the pH value of outlet is ranging from 5.5-7.9.

***Keywords*: Chemical Oxygen Demand, HUASBR, Volatile Fatty Acid, Wastewater.**

I. INTRODUCTION

Contamination of water sources by various pollutants like organic and inorganic pollutants which is a major factor and plays a lead role in global Environmental pollution for a decade. The wastewater management has become critical due to the increase of worldwide population. Hence water quality should be preserved for upcoming generations. Technology for Wastewater treatment has been improving nowadays and it is possible to treat wastewater to a high immensely level efficiently and in a cost constructive way. The anaerobic systems have elicited considerable interest in the recent years based on the reason including good removal efficiencies, simple layout and minimal operating costs. Buzzini et al in 2006 stated that the Granular biomass with prominent methanogenic activity and eminent settling properties can be refined in the reactors [1].

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Start-up process and granulation procedure are the most significant in operation of HUASBR. In the year 2002 study was conducted by Solera et al. had described that during the start-up process of UASB reactor it was due to the influence of temperature on the granulation process [2].

The start-up of HUASB reactor is the time required to achieve an equilibrium condition. This depends on concentration of wastewater i.e. organic load. The main objective to be achieved in the first start-up of high rate anaerobic reactors is to perform an adequate and homogenous immobilization of anaerobic organisms. Comprehensive studies concerning the first start-up of HUASB reactor were both operating under mesophilic and thermophilic conditions. A granular sediment sludge gradually matures on the massive `primary' nuclei which leads to entrapment or intertwinement of recently promoted bacterial matter. This process will be enhanced with more favorable growth condition for the anaerobic organisms (Schmdit and Ahring 1996) [3]. In a next phase of the start-up process which is `secondary' growth nuclei which will be developed by the bacterial films which are attached. Various studies were done with UASBR to reveal the start up process results but it showed during the beginning phase of the process wash out sludge were appreciable and there is a notable drop in the reserve amount of sludge. Both in laboratory experiments as well as in large pilot-plants experiments it was shown (Kennedy and van den Berg 1982) [4] stated that the washed out sludge should not return to the reactor due to the sludge basic specific properties and nature it should wash out again within a few days. The specific activity of the sludge lost from the reactor was close to that of the sludge retained in the reactor. This means that, due to the wash-out the sludge ingredients and significant new bacterial growth developed during the primary phases of the start-up is also lost with the effluent. However, growth will increase gradually on the substantial part of the granulation sludge which results in improving the sludge abundantly later on initial start-up phase. It will be obvious that an unlimited wash-out of sludge cannot be accepted (Patheet al. 1990 [5]; Lettingaet al. 1985 [6]).

Sago waste was given as the feed initially in the startup process to the inlet. Sago, the wholesome starch which is manufactured by tapioca tubers (Mannihot Ulillisema) and it is in the form of globules.

In India about 800 sago mills present in the southern region, producing 15 to 30 tonne of sago per unit per day which were medium and large scale units. About 40,000 to 50,000 lit of effluent per tonne of sago processed. Many investigators observed that the wastewater from sago mills is of serious concern from stream pollution point of view (Murthy and Patel, 1961 [7]; Sastry and Mohan 1963 [8]; Saroja and Sastry 1972 [9]; Gnanapragasam et al. 2010 [10], Senthilkumar et al. 2011 [11]). This research reveals about the reasonable of accelerated start up process under laboratory scale HUASB reactor of stressed loadings. By reducing the start-up time bears practical significance of HUASB applications by saving time and cost. As good granules is a key factor to successful operation of HUASB reactor, influence of accelerated start up under stressed operation pH, COD removal and biogas production was evaluated.

II. MATERIALS AND METHODS

A. Biomass

In this study unknown micro-organisms with methanogenic granular sludge was obtained from the anaerobic digester treating tapioca starch effluent. A granular sludge was completely washed and filtered with a fine filter in order to reduce all the inorganic contents before the reactor was loaded. The volatile suspended solids content of the sludge was then approximated around 6000 mg/lit (APHA 2005 [12]).

B. Digester Configurations

Owing to prior knowledge and the ample advantages of the HUASB reactor, it was decided to utilize a laboratory scale HUASB reactor for this study was designed and fabricated using Perspex tube (Figure 1).

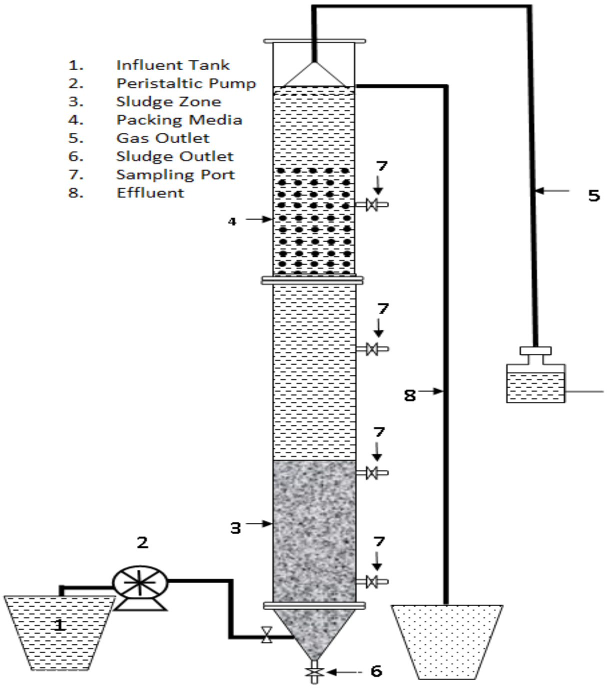

Fig. 1 Schematic diagram of HUASB reactor

Reactor with effective volume of 20 L and the total height of the reactor was about 1.42 m. The effective height and the diameter of the reactor are 1.17m and 0.15m, respectively. The solid-gas-liquid separator (GLSS) were placed in the top portion in the arrangement by inverted conical funnel for bio gas collection which is produced by anaerobic digestion and also to prevent the loss of granules. The amount of gas produced is measured by water displacement method. About 20ppm of peristaltic pump was used to achieve the constant discharge flow in the reactor. The top third segment of reactor was filled with bio-ball as support media. 152 pieces of black bio-ball were used as attached growth media of same size which has a diameter of about 2.8 cm, a specific area of 550 m2/m3, and porosity hollow of 0.97. This bio-ball prevents the escape of bio granules from the reactor. Totally 5 sampling ports were installed for ease collect of sample for analysis at different heights. The reactor was operated at 31º C to 35º C.

C. Substrate and Nutrients

In the present study substrate like Nitrogen $(NH_4)_2SO_4$and Phosphorous KH_2PO_4 were added with the chemical oxygen demand: Nitrogen: Phosphorous ratio of 550:5:1. The stock solution of trace nutrients containing ferric chloride, zinc sulphate, copper sulphate etc. were added about 1.0 ml /l of the feed solution to the reactor (Ahn 2003) [13]

III. RESULT AND DISCUSSION

A. pH

Fig 2 represents the pH concentrations of both inlet as well as outlet of the reactor. The pH of the feed is about 5.54 to 7.12, which is suitable for the growth of micro-organisms.

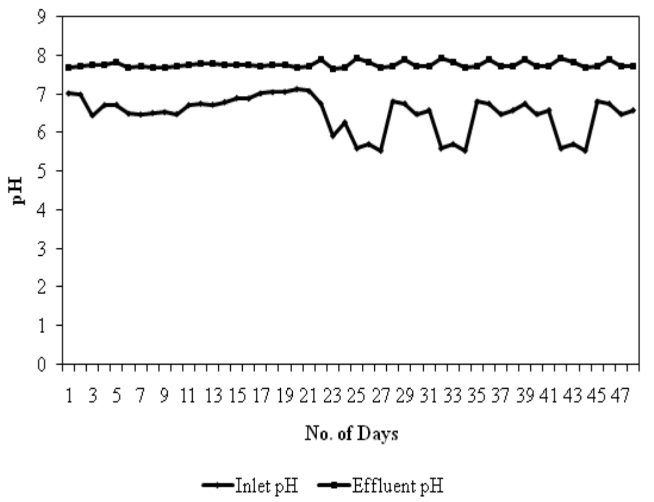

Fig. 2: pH concentration of the reactor during start-up period

From fig 2 pH of the reactor outlet was more or less equal to pH of feed for first 23 days after the start-up and 24th day onwards pH of the inlet varies vary much but the outlet pH are maintained as constant.

The outlet pH was alkaline condition (7.6 – 8.0), during the initial start-up pH of methanogenic reactor was in the level of 7.6 and as the time increases the pH also get slightly increased and maximum pH was attained from 22nd day onwards this indicates the steady state operation of the reactors. Solera et al. (2002) [2] had stated that the pH optimized for the methanogenic reactor were 7.7-7.8 throughout the initial period of two phase process. The pH was one of the valid observations during anaerobic process. The main reason for not increase in pH for initial days are due to accumulation of volatile fatty acid (Ravichandran and Balaji 2018; [14] Gnanapragasam et al. 2011 [15]). From the result we can conclude that the reactor was operated at stable condition.

B. Removal of COD

Fig 3 shows the COD concentration of the feed, acidogenic outlet and methanogenic outlet of the HUASB reactor.

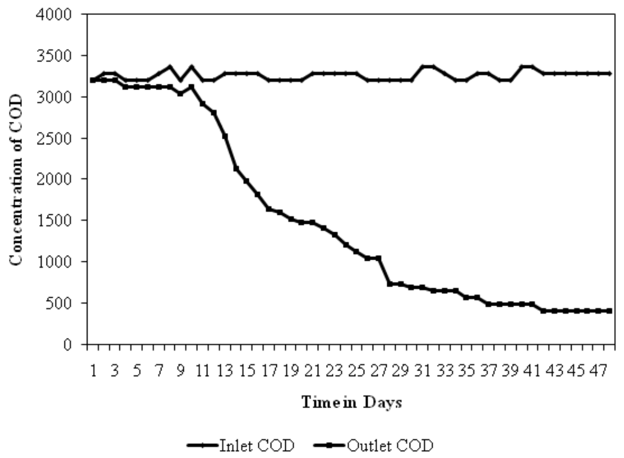

Fig. 3: COD concentration of the reactor during start-up period

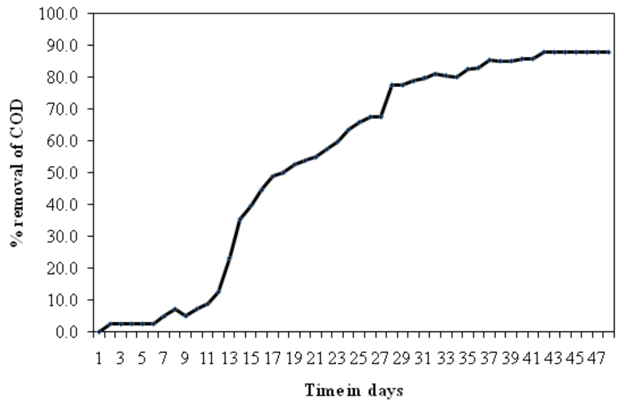

Fig. 4 COD removal efficiency of the reactor

From figure 3 the COD level of feed ranging 5200 – 5600 mg/l, for acidogenic outlet was about 2320 – 5120 mg/l and for methanogenic outlet was about 800 – 4800 mg/l. Fig 4 shows COD the removal efficiency of the reactor during the start-up period. From figure 4 it was evident that from the second day the reactor start up steadily i.e. COD removal was efficiently occurred from first day and increases gradually upto 41st day and attains the constant removal on 42nd day onwards. 87.8 % of COD removal which is maximum level attains at the start up period. In the year 2004 Show et al [16] had stated that 80% which was the highest COD removal was achieved. About 80% of COD removal was achieved by Ahn and Specee (2003) [17] within 30 days of start-up period using anaerobic granules.

C. Volatile Fatty Acid (VFA)

The VFA concentrations at bottom and top of the reactors were shown in Fig. 5. Acetic and Propionic acids make up the bulk of volatile acids accumulated inside the reactors (Show et al. 2004) [16]

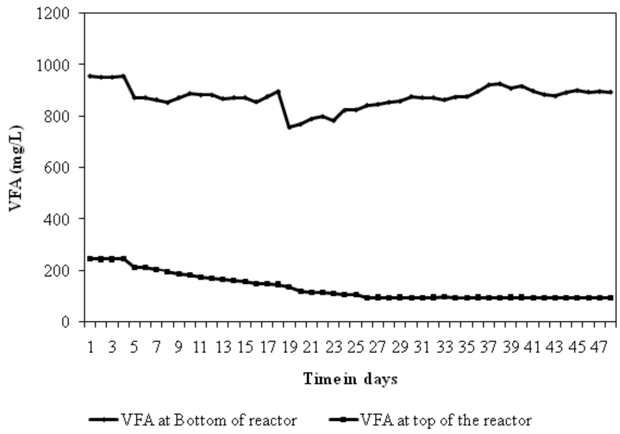

Fig. 5 VFA of the reactor

From Fig 5 it was evident that the volatile fatty acid at bottom of the reactor was high (956 mg/l) on the first day of start-up and reduces slightly upto 756 mg/l at 19th day. At top of the reactor volatile fatty acid ranges from 92 mg/l to 246 mg/l. Initially volatile fatty acid shows little elevated as the height increases the volatile fatty acid got reduced and it reaches the stable condition at the end 48th day. In 2006 speece found that to operate UASBR in the stable condition, VFA should less than 250 mg/l [17]. The accumulation of VFA will cause decrease efficiency of reactor so it must be converted immediately (Duttaet al. 2018) [18].

D. Biogas

Figure 6 shows the biogas production during the start-up period of pilot scale HUASB reactor. From Figure 6 it was clear that the biogas production for first 17th days was very less and after 18th day of the start-up the production of biogas was increased which shows the methanogenic reactor in stable. In 17th days the production was in the level of 6.4 lit /day and from 18th to 48th day the biogas production reaches 13.2 l/d. The study was conducted by Senthilkumar et al (2009) stated that the biogas production was about 27 l/d using a bench scale reactor of 15 l total volume using starch wastewater as substrate during start-up period [19]

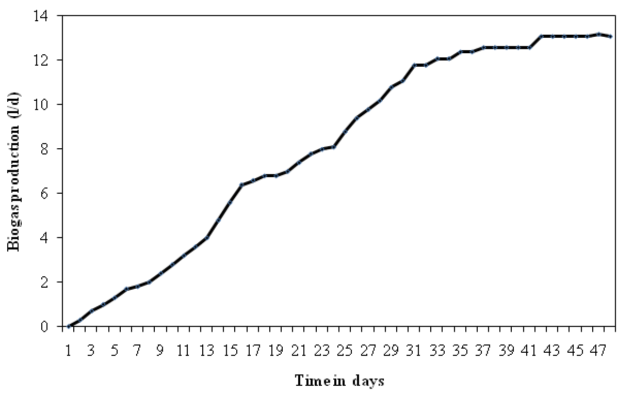

Fig. 6 Biogas produced during start-up of reactor

IV. CONCLUSION

This study concludes that the feasibility for the analysis of high strength soluble wastewater with COD values higher than 3000 mg/l of UASB system. 87.8 % COD was achieved during start-up process. The pH and volatile fatty acid reactor was in the constructed conditions through the process. The biogas was observed as 13.2 lit/day and the biomass activity was found to be very well at this organic loading rate of 3.2 kg COD/m3.d. Several studies were done in this field for treating high strength industrial wastewater like pharmaceutical, dairy, sago wastewater using Hybrid reactors. From the above results it was confirmed that an UASB reactor start-up can be made with a short period efficiently.

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