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REVIEW ON APPLICATIONS OF UASB TECHNOLOGY FOR WASTEWATER TREATMENT

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ABSTRACT:

Up-flow Anaerobic Sludge Blanket (UASB) reactor is one of the anaerobic process. In this anaerobic treatment complex organic matter is get converted into methane gas through the stages like hydrolysis, acidogenesis and methanogenesis. UASB is widely applicable for treating various types of wastewater. UASB has advantages over aerobic treatment. In this present review applications of UASB are explained for wastewater like sugar industry, distillery, dairy industry, slaughter house and high strength municipal wastewater. Under this review removal efficiency of COD (Chemical Oxygen Demand) is studied for various organic loading and Hydraulic Retention Time (HRT).

Keywords: UASB, Hydraulic Retention Time, Organic Loading Rate, Temperature, COD.

1. INTRODUCTION:

India facing severe problems of collection, treatment and disposal of effluents due to rapid industrialization and urbanization. Two types of treatments can be done on effluents i.e. Aerobic treatment and Anaerobic treatment, but in aerobic treatment external energy is required for aeration also there is excess sludge production in aerobic treatment. Aerobic treatments are widely applicable for treating high strength waste water. It does not require external energy and it itself produces the energy in the form of methane gas. UASB is one of the anaerobic treatment converts the waste water organic pollutants into small amount of sludge and large amount of biogas as a source of energy (Hampannavar and Shivayogimath, 2010). Responsible parameters for the good performance of UASB are formation of compact granular sludge which ensures high specific methenogeric activities and superior settling characteristics (Jinye et al., 2008). UASB is applicable for treating variety of industrial wastewater i.e. Sugar industry waste water, dairy waste water, textile waste water, slaughterhouse waste water, oil industry waste water, potato processing waste water, distillery waste water and recent research indicate the feasibility of UASB process in treatment of domestic effluents also.

2. UASB process:

Mainly in there are four key biological and chemical stages in UASB process i.e. Hydrolysis, Acidogenesis, Acetogenesis and Methanogenesis.

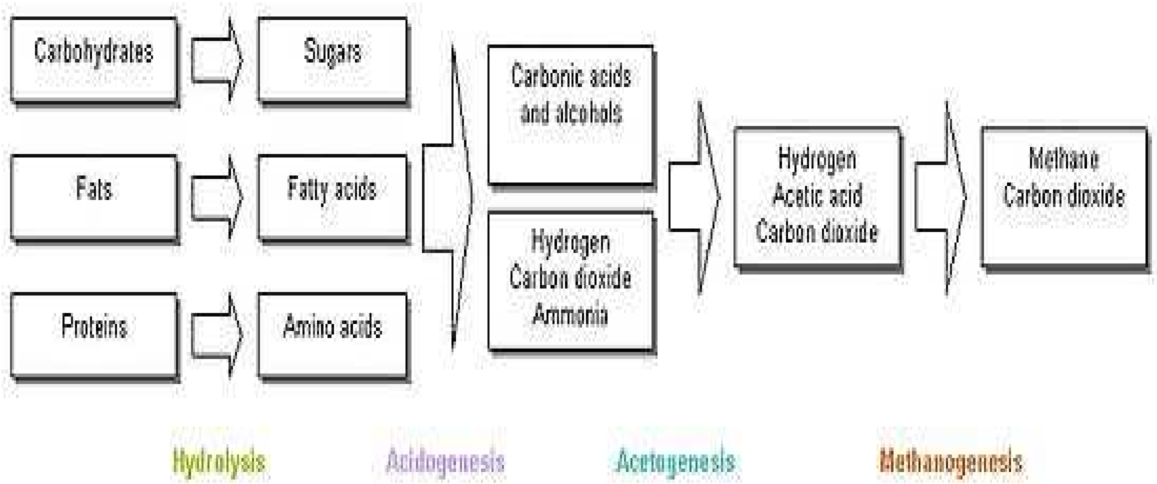

Fig.1 UASB process stages

Hydrolysis:

Mostly organic concentration of wastewater is complex in nature. For the bacteria in anaerobic digesters to access the energy potential of the material, these complex organic constituents should break down into their smaller constituent parts. These constituent parts, or monomers, such as sugars, are readily available to other bacteria. The process of breaking these chains and dissolving the smaller molecules into solution is called hydrolysis. Through hydrolysis the complex organic moleculesare broken down into simple sugars, amino acids, and fatty acids. Acetate and hydrogen produced in the first stages can be used directly by methanogens. Other molecules, such as volatile fatty acids with a chain length greater than that of acetate must first be catabolised into compounds that can be directly used by methanogens.

Acidogenesis:

The biological process of acidogenesis results in further breakdown of the remaining components by acidogenic (fermentative) bacteria. Here, vfas are created, along with ammonia, carbon dioxide, and hydrogen sulfide, as well as other byproducts.

Acetogenesis :

The third stage is acetogenesis. Here, simple molecules created through the acidogenesis phase are further digested by acetogens to produce largely acetic acid, as well as carbon dioxide and hydrogen.

Methanogenesis:

The terminal stage of anaerobic digestion is the biological process of methanogenesis. Here, methanogens use the intermediate products of the preceding stages and convert them into methane, carbon dioxide, and water. These components make up the majority of the biogas emitted from the system. Methanogenesis is sensitive to both high and low pH and occurs between pH 6.5 and pH 8. The remaining, indigestible material the microbes cannot use and any dead bacterial remains constitute the digestate.

A simplified generic chemical equation for the overall processes outlined above is as follows:

$$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$$

3. UASB controlling factors:

3.1 pH

The pH value is significantly affected the UASB reactor performance and stability. pH for this treatment is between the range of 6.3-7.8. The change in pH of influent is mainly an important factor for system stability. Raising the pH value by adding NaOH is also done to increase the ph up to 7.4 to obtain increasing in the gas production, with decreasing in CO_2 production. (Habeeb et al., 2010)

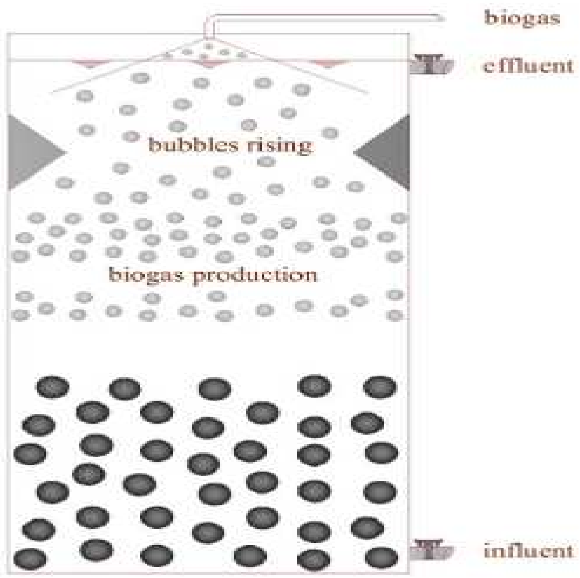

Fig.2 Schematic diagram of UASB reactor

3.2 Mixing

Good attachment between biomass and substrates is mainly attributed by mixing process. Mixing gives more opportunities of attachment by recycling biomass as well as activating dead zones in sludge bed which is mainly inhibited the phenomenon of channelling Mixing can be achieved through biomass recirculation, mechanical mixing, or slurry recirculation. Rapid mixing is considered undesirable mixing indicating that it causes a biomass. (Habeeb et al., 2010)

3.3 Temperature

The efficiency of the anaerobic process is highly dependent on reactor temperature. The rate of degradation of organics is enhanced at mesophilic temperatures. The mesophilic temperature varies between 30-40ºC. However, the effect of temperature is mainly governed by various physical, chemical, and biological processes taking place in the reactor. A sharp drop in methane generation appears as the reactor temperature exceeds 45ºC because of bacterial decay at higher temperatures ranging from 45 to 65ºC. The effect of temperature on the efficiency of the anaerobic process is governed by the reactor type as well. A decline in UASB efficiency at low temperature can be explained due to decreases in biological activity. (Yasar and Tabinda, 2010)

3.4 **HRT**

The hydraulic retention time is significantly considered as the key operating parameter where its effectiveness is mainly controlling the performance of UASB reactor. The HRT is defined as the amount of time for which the wastewater is retained in the reactor for digestion and is computed by dividing the volume of the reactor by the influent flow rate. The UASB reactor gives high COD removal at very short HRT. However, it is a function of effluent characteristics, which vary from industry to industry. (Yasar and Tabinda, 2010)

4. Applications of UASB

4.1 Sugar Industry Wastewater:

This wastewater having ph 4.6 to 7.1, reddish yellow liquid with COD 600 to 4380 mg/L and BOD 300 to 2000 mg/L. Sugar industry effluent when discharged in streams, rapid depletion of oxygen due to biological oxidation takes place and it emits the offensive odor and affects on fish mortality (Rao and Dutta, 1987).

Hampannavar and Shivyogimath studied the paper on "Anaerobic treatment of Sugar Industry Wastewater by Up flow anaerobic sludge blanket reactor at ambient temperature". In this study lab scale UASB is developed of volume 7.5 litres. The ambient room temperature during the study period is between 29 to 37^0C. The reactor is started with an OLR of 0.5g COD/ L. D and loaded up to 165g COD/ L. D. HRT 48 hrs is kept constant at an OLR 0.5 5g COD/ L. D during start up. Then OLR is increased from 0.5 to 1 within decrease in HRT from 48 h to 24 h during first 35 days. Then further HRT is reduced from 24 h to 6 h with increase in OLR up to 16g COD/L. D. Maximum COD removal efficiency achieved is 89.5% and optimum HRT is found 6 hrs. Maximum volumetric biogas production is 4.66 L/L. d at OLR of 16 5 g COD/ L. d.

Nacheva et al., studied "Treatment of cane sugar mill wastewater in an up flow anaerobic sludge bed reactor". Experimental work is carried out in UASB reactor of volume 80 L with effective volume of 50 L. Four organic loadings are applied to the reactor i.e. 4, 8, 16 and 24 kg COD/m^3.d. At OLR 4 kg COD/m^3.d, COD removal efficiency obtained 97% with good biogas production. As organic loading increased further removal efficiency initially decreased by 18% but after 10 days period COD removal efficiency obtained 92-96%. Organic loading up to 16 kg COD/m^3.d removal efficiencies obtained more than 90%. At OLR 24 kg COD/m^3.d COD removal efficiency obtained is between 78-82% because VFA concentration is increased with high OLR.

4.2 Dairy Industry Wastewater:

Dairy waste water is generally organic in nature. When dairy waste water discharged in stream without any treatment a rapid depletion of dissolved oxygen content of stream occurs along the development of sewage fungi at bottom of stream. Milk waste becomes acidic due to decomposition of lactose into lactic acid under anaerobic condition. This results casein from waste which further decompose highly odorous black sludge. Gotmare et al., studied "Biomethanation of dairy wastewater through UASB at mesophillic temperature range". In this study UASB reactor is used with volume of 120.12 m^3. In this the digester efficiency of treating dairy waste water at organic loading rates is studying and its performance is assessed by analyzing ph, dissolved COD, BOD, TSS, VFA and biogas production. The reactor achieved COD, BOD and TSS removal efficiency obtained 87.06%, 94.50% and 56.54%, respectively. The average gas production and methane gas conversion at optimum conditions is obtained 179.35 mg/l and 125.55 mg/l respectively.

Gavala et al., studied "Treatment of Dairy wastewater Using an Up flow Anaerobic Sludge Blanket Reactor". A 10 L UASB reactor is developed of plexiglass for this experimental work. Reactor is inoculated with anaerobic mixed liquor from dairy wastewater and glucose fed digesters. At OLR of 6.2 g COD/ L. D and HRT of 6 d, COD removal efficiency obtained up to 98%. When OLR is increased to 7.5 g COD/ L. D, the COD removal efficiency is reduced to 85-90%. After this increase in OLR results in decrease in COD removal efficiency and also decrease in biogas production and ph value. Therefore 6.2 g COD/ L. D OLR for UASB reactor treating dairy wastewater is safe and it can be increased to maximum of 7.5 g COD/ L. D.

4.2 Distillers grain Wastewater:

This waste water is acidic having ph 3 to 4.3 and high concentration of COD i.e. 90000 to 210000 mg/l, high BOD 45000 to 100000 mg/l and emits obnoxious odor when discharged in waste streams gives immediate discoloration and depletion of dissolved oxygen posing serious threat to the organic flora and fauna (Mane et al., 2006). Gao et al., studied "Performance evaluation of a mesophilic up flow anaerobic sludge blanked reactor in treating distillers grain waste water". For this present study UASB reactor of acrylic plastic is developed with working capacity of 8.18 liters. During experimental work temperature in the reactor was kept 37^0C by heat exchanger. The reactor is inoculated by seeding sludge from a anaerobic digester in a sewage treatment plant. OLR is increased firstly from 0.42 to 5.6 kg COD/m^3.d at HRT of 2.5 day and there is increase in COD removal efficiency from 78.3 to 93.8% along with methane production rate from 0.2 to 2.31 L CH_4 /L.d. After OLR is increased extremely from 5.6 to 10.8 kg COD/m^3.d there is decrease in COD removal efficiency and methane production rate and UFA accumulation in the effluent. Further OLR is reduced to 1.8 kg COD/m^3.d after addition of sodium bicarbonate to the influent. After successful start up 80 to 97.3 % COD removal, efficiency is achieved at HRT 82 to 11 hrs with OLR 5 to 48.3 kg COD/m^3.d

4.4 High-Strength Municipal Wastewater:

Hossein et al., studied "Optimizing OLR and HRT in a UASB Reactor for pretreating High Strength Municipal Wastewater". This wastewater has pH between 7-8, COD in the range 600-2400 mg/L, TSS in between 190-250 mg/L, nitrate 4-25 mg/L. In this study a lab scale UASB reactor is developed with volume of 5 l. Different organic loadings are done i.e. 3.6, 7.2, 10.8 and 14.4 kg COD/m^3.d. Hydraulic Retention Time (HRT) is also varied like 3, 4, 5 and 6 hours. The removal efficiency of COD, nitrate, sulfate and TSS is investigated for determining the optimum organic loading and HRT. The removal efficiency of COD, sulfate and TSS is obtained 80%, 80% and 70% respectively at HRT of 4 hrs. COD removal efficiency is maximum at organic loading range of 7.2 to 10.8 kg COD/m^3.d. For this range COD removal is about 85%. It represents optimum organic loading range for the UASB reactor is 7.2 to 10.8 kg COD/m^3.d. Nitrate removal efficiency is 80% at optimized organic loading range.

Ruiz et al., studied **"**Performance of and biomass characterisation in a UASB Reactor treating domestic waste water at ambient temperature". Domestic waste water is treated anaerobically in a laboratory-scale up flow anaerobic sludge blanket digester, at temperature 20°C, at hydraulic retention times of longer than 24 h. Active volume of UASB reactor is 2 l and it is located in a thermostat-controlled chamber at 20°C. Anaerobic sludge is used as seed in the UASB reactor. At HRT 24 h the COD and SS removal efficiencies remained practically constant and higher than 85%. At first reactor is operated at low organic loading and then OLR is increased progressively up to 3 g

COD/l· d, by increasing the flow rate with decreasing the HRT down to 5 h. When HRT reduced from 24 to 5 h, the COD removal decreased from 85% to 53% and the SS removal from 89% to 63%. The methane recovered in the biogas ranged from 25% to 30% of the influent COD, increasing slightly with the operational time. The average methane content of the biogas obtained is 80%. The methane production recovered in the gas phase reached 0.20 l CH4/l· d at the maximum OLR applied. The amount and the methanogenic activity of the developed anaerobic sludge appeared to be the main efficiency-limiting factor of the UASB performance.

4.5 Slaughterhouse Wastewater:

Torkian et al., studied "Performance evaluation of a UASB system for treating slaughterhouse wastewater". In this present study pilot scale UASB is developed of effective volume 500 liters for the treatment of slaughterhouse wastewater. The reactor is inoculated with 200 liter sludge from a municipal anaerobic digester. Removal efficiency of COD occurred up to 80% at an OLR 6.9 kg COD/m^3.d. Further OLR is increased to 14.2 kg COD/m^3.d for 109-130 days and 25 kg COD/m^3.d for days 131-143 did not cause any reduction in performance and COD removal efficiency 83 and 87% obtained respectively at temperature 31-35^{0}C. Gas production is 50 L/d in the initial phase at temperature 15^{0}C and 900 L/d at 25^{0}C. High OLR can be tolerated by the UASB system for short period of time and for stable operations OLR should be maintained below 20 kg COD/m^3.d. Up flow velocity is close to 1 m/hr to improve microbial activity and HRT is in between 6-8 hr for getting the sufficient contact time between wastewater and microbial population.

Nacheva et al., studied "Treatment of slaughterhouse wastewater in up flow anaerobic sludge blanket reactor". In this study up flow anaerobic sludge blanket reactor is operated at ambient temperature i. E 20.9-25.2°C The experimental work is carried out in a reactor with 15 L effective volume. Four organic loads are applied to reactor and the process performance is evaluated. The COD removal rate increased with the load rise from 4 to 15 kg COD/m^3.d. Removal efficiencies of 90% were obtained with a load of 15 kg COD/m^3.d. At first two stages in proportion during the first two stages due to the low up flow velocities the entrapment of suspended solids in the sludge blanket is greater. The Wastewater alkalinity of the reactor was enough therefore the concentrations of the volatile fatty acids is not high. The yield coefficient of methane production increased with the load rise, reaching 0.266 m^3/kg COD (removed) at 15 kg COD/m^3.d organic load. The UASB reactor is a good option for the biological treatment of slaughterhouse wastewater.

5. CONCLUSION:

UASB reactor is feasible for treating variety of wastewater. Performance of UASB reactor is get affected by ph, HRT, OLR, temperature and VFA to alkalinity ratio. Proper HRT should be provided to give sufficient contact time between wastewater and bacteria. For avoiding VFA accumulation in UASB reactor and for getting effective biogas production sodium bicarbonate alkalinity should be provided. VFA to alkalinity ratio should maintained between 0.5 - 0.8 for good performance of UASB reactor.

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