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A Review Article on Effect of Sulfate on the Efficiency of UASB Reactor Treating Domestic Waste Water

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Abstract : Up Flow Anaerobic sludge blanket (UASB) reactor is widely used around the world to treat various domestic as well as industrial waste water. With advantages like production of biogas, no needs of support structure for development of microorganisms and high rate of biomass etc. However different range and parameter influence the performance of UASB. The purpose of this study was on the effect of sulfate on biogas production and COD removal in UASB treating Domestic wastewater. The Process in anaerobic treatment and process parameter of UASB reactor were discussed in this work. Sulfate effect on UASB process with reference to Methane production and H_2S generation were discussed. The COD/So_4^{2-} ratio effect on UASB reactor process were also discussed in this.

***Keyword**-COD, Domestic wastewater, Methane, Sulfate, UASB*

1. Introduction

Waste water to be treated is inlets at bottom with up flaw direction through an activated sludge in the reactor, which is generally in the form of granular blanket. The activated sludge blanket have good stability at suspended form and do not get washed out under high velocity condition and therefore provide good treatment efficiency when the waste water comes in contact with the sludge blanket. The gases produced under anaerobic condition cause internal mixing, which helps in the formation and maintenance of biogas granular and gas-liquid-solid separator is added on the top of the reactor for the effective segregation gas, liquid and granular. (Daud et al., 2018).

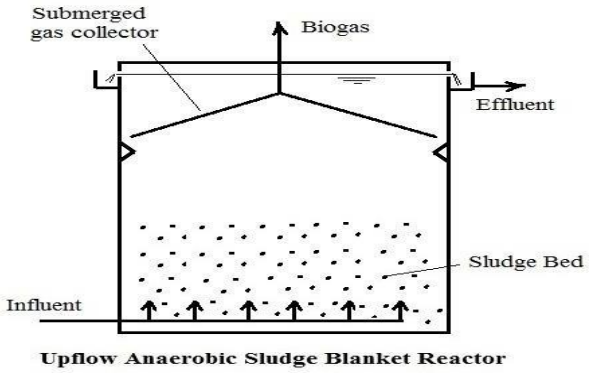

Figure 1 Schematic diagram of a UASB Reactor

(Source:https://www.engineeringexcelspreadsheets.com/wpcontent/uploads/2017/05/Flow-Diagram.jpg)

Anaerobic treatment is a biological process in which anaerobic microorganisms break the organic material in the absence of oxygen. Once of the end product is biogas, which is combusted to generate electricity and heat, or can be processed in renewable natural gas and transportation fuels. (Abdelgadir et al., 2014)

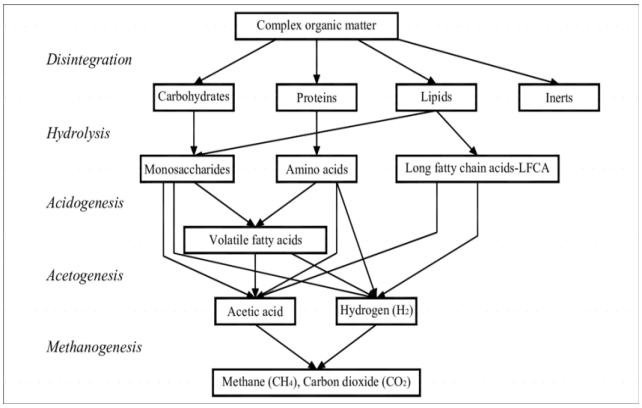

Figure 2 Anaerobic Digestion process flow

(Source:https://www.researchgate.net/figure/A

naerobic-Digestion-process-flowchart_fig2_268741265)

Although the presence of sulfur compounds is vital for biosynthesis reaction, high sulfate concentration in fed may cause inhibitory effect on anaerobic reactor and units. Furthermore, the produced sulfide causes sludge bulking in the activated sludge post-treatment unit due to the growth of sulfide oxidizing bacteria. Hydrogen sulfide is also highly corrosive and has obnoxious order. The inhibitory effect of sulfate ions might be different as various reaction tack place. Sulfate ions enhance SRB to grow rapidly and become a competitor for MPB(Shayegan et al., 2003). UASB efficiency is affected by increasing sulfate ions. As a consequence, for wastewater containing high BOD concentration and sulfate ions, although the anaerobic treatment may be an appropriate choice, the high concentration of sulfate ions may cause problem with respect to UASB efficiency(Shayegan et al., 2003).

The influent COD to $SO4^{2-}$ ration is an important parameter affecting the competition between sulfate reducing bacteria and other anaerobic bacteria involved in anaerobic waste water treatment. COD/SO42- ration higher than 10 is necessary for successful anaerobic treatment.(Hu et al., 2015)

2. Critical Literature Review

The literature review is on UASB efficiency depending on various parameter and that directly or indirectly affect on methane production. Then major finding has been stated, explaining the very significant finding of this literature review stating their advantaged and factor affecting

- **(Gnanadipathy & Polprasert, 1993**)This study was a feasibility of employing pilot-scale up flow anaerobic sludge blanket (UASB) reactors to treat a domestic (or relatively low-strength) wastewater. Four 30-1 UASB reactors, each with a 0.15-m inner diameter and 2-m height were used in this study which was conducted at an average ambient temperature of 30^{o}C. Three reactors were inoculated with different types of seed sludge, namely: sludge from a facultative waste stabilization pond, anaerobically digested sludge and sludge from a UASB reactor treating a distillery wastewater. The fourth reactor was started without inoculums and was

studied for possible self inoculation. Domestic wastewater was mixed with a stock glucose solution to increase the influent COD concentrations to about 600 mg/l. All four reactors were started with a hydraulic retention time (HRT) of 24 h, and this HRT was later reduced to 12, 6 and 3 h, consecutively, corresponding to the organic loading rates (OLR) of 0.4-0.6, 0.9-1.4, 1.8-2.8 and 3.6-6.0 kg COD/(m3.d), respectively. At the highest OLR or shortest HRT, there was about 90% removal of the influent COD in Reactors 1-3 while the methane (CH,) production rate was found to be 150 NI/kg COD removed with a methane (CH4) content of 75%. Reactor 4, without inoculation, could not develop sufficient amount of biomass to withstand the high OLR and its performance deteriorated at the HRT of 3 and 6h.

- **(Daud et al., 2018)** The author research that process parameters such as temperature, hydraulic retention time (HRT), organic loading rate (OLR), sludge retention time, pH, granulation, and mixing are effects on the performance of UASB reactor.
- **(Jenicek et al., 2007)**Presence of sulphates (soluble or insoluble) in reacting milieu should be avoided as their reduction by sulphate reducing bacteria to hydrogen sulphide can increase H_2S contents in biogas to very high values.
- **(Owusu-Agyeman et al., 2019)**This study was carried out to investigate the relationship between the methane producing pathways and the characteristics of anaerobic granules treating municipal wastewater. For this purpose, two pilot scale up flow anaerobic

sludge blanket reactors with different granule size distribution (1– 2mm and 3–4 mm) were investigated at operating temperatures of 20 °C and 28 °C for 239 days. There was an increased and stable biogas production when the temperature was elevated to 28 °C likely due to a reduction in methane solubility.

- **(Isa et al., 1986)** The effect of different Sulfur compounds on methane production relative to sulfate reduction in high-rate anaerobic digestion was evaluated. High free H_2S affected the sulfate-reducing bacteria. Format and acetate supported the sulfate-reducing bacteria very poorly.
- **(Shayegan et al., 2003)** UASB reactors R1, R2, R3 and R4 were used to study the effect of sulfate concentration on granule formation. Diluted molasses with COD range 00.1300 mg/ l were used as feed and acclimated cow manure was used as seed. Concentration of sulfate ions increases in the four reactors were 100, 500, 1000 and 1500 mg/l range. sludge Granules blanket were observed in R2 after 33 days from startup time, while in R1 and R3 granules appeared after 45 days. No sludge Granules blanket were formed in R4. Sulfate reduction efficiencies were 84, 89, 71.5 and 59.4 % while corresponding COD removal efficiencies were 85, 91, 84 and 77% for reactorR1 to R4 respectively. Temperature kept at 30ºC all experiments and the best pH for granulation was found to be 7.00.
- **(C. L. Souza et al., 2012)**The release of CH_4 and H_2S in UASB reactors was evaluated with the aim to quantify the emissions from the liquid surfaces (three-phase separator and settler compartment) and also from the reactor's discharge hydraulic structures. The studies were carried out in two pilot- (360 L) and one demo-scale (14 m3) UASB reactors treating domestic wastewater. As expected, the release rates were much higher across the gas/liquid interfaces of the three-phase separators (5.4–9.7 kg CH_4 m/d and 23.0–35.8 g S m/d) as compared with the quiescent settler surfaces (11.0–17.8 g CH_4 m_2 d_1 and 0.21 to 0.37 g S m/d). The decrease of dissolved methane and dissolved hydrogen sulfide was very large in the discharging hydraulic structures very close to the reactor (>60 and >80%, respectively), largely due to the loss to the atmosphere, indicating that the concentration of these compounds will probably fall to values close to zero in the near downstream structures.
- **(B. Brahmacharimayum 2014)** author studied sulfate reduction and sulfide oxidation potential were observed over a period of 35 months. Regarding the sulfate reduction efficiency, the PBR was able to achieve more than 90% sulfate reduction could be achieved with 2000 mg/L sulfate concentration when lactate was used as the carbon source. The formation of elemental sulfur was observed even in anaerobic condition which might be most probably due to the reaction between the sulfides and sulfites.
- **(Jing et al., 2013)** author find an appropriate method for sulfate-rich wastewater containing ethanol and acetate with COD/sulfate ratio of 1, a UASB reactor was operated for more than 180 days. The results indicated that this system removed more than 80% of COD and 30% of sulfate with HRT above 6 h and OLR below 12.3 g COD/L d. Further HRT decrease caused volatile fatty acids accumulation and performance deterioration. Except at HRT of 2 h, COD and electron flow were mostly utilized by methane-producing archaea (MPA), and methane yield remained in the range of 0.18–0.24 LCH_4/g COD.
- **(Hu et al., 2015)**The effect of the chemical oxygen demand/sulfate (COD/SO42_) ratio on the anaerobic treatment of synthetic chemical wastewater containing acetate, ethanol, and sulfate, was investigated using a UASB reactor. The experimental results show that at a COD/SO42_ ratio of 20 and a COD loading rate of 25.2 g COD L d, a

COD removal of as high as 87.8% was maintained. At a COD/SO42_ ratio of 0.5 (sulfate concentration 6000 mg L), however, the COD removal was 79.2% and the methane yield was 0.20 LCH4 g COD. The conversion of influent COD to methane dropped from 80.5% to 54.4% as the COD/SO4 ratio decreased from 20 to 0.5. At all the COD/SO42_ ratios applied, over 79.4% of the total electron flow was utilized by methane-producing archaea (MPA), indicating that methane fermentation was the predominant reaction.

- **(M. E. Souza, 1986)** this paper describes and discusses the principal ideas and parameters related to the application, design and operation of wastewater treatment systems using the up flow anaerobic sludge blanket reactor (UASB).
- **(Zhao, 2011)** This study evaluates the effect of temperature on biogas production and COD total removal in Line 4-UASB system treating domestic wastewater in Hammarby Sjöstadsverk. The biogas production analysis is focus on UASB 1. Temperature rising from 19°Cto 35°C achieves a general benefit result in methane yield rate and COD total removal efficiency. The best methane yield rate and COD total removal rate are 0.167l/g COD total and 56.84% respectively at highest working temperature 33.4°C with OLR 3.072gCODtotal/(l*day) and HRT 4.2h.
- **(van den Brand et al., 2018)** this study evaluates the proliferation of SRB at pilot-scale in a moderate climate. These studies revealed that SRB were present and active in the pilot fed with domestic wastewater at 13°C, and outcome Methanogens. Stable, smooth and well-settled granule formation occurred, which is beneficial for full- scale application.

3. Conclusion

The effect of Sulfate on UASB is as same as other process parameter. As per literature study the sulfate is directly effect on methane producing bacteria that is indirectly on anaerobic process which is organic matter decomposition decreases, also sulfate inhibitory effect in UASB reactor which effect on process parameter of UASB reactor. $COD/SO4^{2-}$ ratio is effect on COD removal efficiency and Sludge blanket. More sulfates generate more H_2S in biogas production which decrease the energy recovery in UASB reactor. H_2S highly corrosive and have obnoxious order.

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