DEVELOPMENT OF DESIGN CRITERIA FOR UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR APPLICABLE TO HIGH STRENGTH INDUSTRIAL WASTEWATER

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By

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DECLARATION

I certify that this dissertation does not incorporate without acknowledgement of any material previously submitted for a Degree or Diploma in any University and to the best of my knowledge and belief it does not contain any material previously published or written or orally communicated by another person except, where due reference is made in the text.

E.K.CHAMPIKA

Admission No: 06/8006

Certified by

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Prof. (Mrs.) N.Ratnayake
(Supervisor)

ABSTRACT

Industrial wastewaters are complex in nature, having soluble, insoluble and/or potentially insoluble compounds, which may be biodegradable or not and which may give rise to foaming or scaling. Industrial wastewaters with Chemical Oxygen Demand (COD) greater than 1500 mg/l are generally categorized as high strength industrial wastewaters.

In the present research, a laboratory scale study on COD removal in a 12.04 liters capacity UASB was investigated for a period of 236 days. The study was carried out at ambient temperature (approximately 28^0 C) and the reactor was inoculated with the seed sludge obtained from a working anaerobic digester treating brewery wastewater. Two trials were conducted: The first trial (T 1) was continued for 151 days and the second trial (T 2) for 85 days.

T 1 comprised 11 sub experimental runs (R0-R10), R0- R2 were the "Flow Through" acclimatization period in which the flow rate was maintained at 300 ml/hr. From R3-R10 the flow rate of the reactor was increased at 150 ml/hr steps. The reactor was operated continuously with COD removal efficiencies 60%-70%, until the flow rate was increased up to 750 ml/hr in the period R6. During the period of R6 sludge wash out was evident with reactor acidification. However the reactor recovered in 10 days period. Nevertheless, COD removal efficiencies were around 50% and periodic sludge washouts were experienced. Therefore the reactor operation was stopped and recommenced with fresh sludge.

In the T 2 trial, "Batch" acclimatized sludge was used as inoculum. The organic loading rate (OLR) was maintained in the range of 10-15 kg COD/m^3.day at a flow rate of 900 ml/hr and influent COD was varied in the range of 5000-9000 mg/l. The reactor showed stable COD removal efficiency of 70-75%. Effluent recirculation was successfully used as an alternative for alkalinity supplementation by chemicals by employing a 0.5:1 recirculation ratio.

The methane yields observed in both trials were low compared with the theoretical value of 0.35 CH_4 l/ g COD removed at Standard Temperature and Pressure, but in second trial methane yield showed a trend of increment indicating some growth of methanogens.

The reactor showed a satisfactory COD removal efficiency at OLR s of 10-15 kg COD/ m^3.day in this study. However it did not show a satisfactory outcome as an energy recovering technique. Further studies must be carried out on that aspect.

According to the results it can be recommended that by using upflow velocity of 0.129 m/hr and influent pH range of 7-7.2 OLR s up to 15 kg COD/m^3.day can be handled successfully in a UASB reactor. For maintaining influent pH in the above range no added chemicals are needed, but an effluent recirculation ratio of 0.5:1 can be employed.

Key words: UASB, COD, High strength industrial wastewater

Annex 1

Calculation for Theoretical Methane Yield

Calculation of COD equivalent of Methane

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

16 g 64g

16 g CH_4 ~ 64 g O_2 (COD)

1 g CH_4 ~ 64/16 = 4 g COD

Conversion of CH_4 mass to equivalent volume

Based on gas law, 1 mole of any gas at STP (Standard Temperature and Pressure) occupies volume of 22.4 l.

1 Mole CH_4 ~ 22.4 l CH_4

16 g CH_4 ~ 22.4 l CH_4

1 g CH_4 ~ 22.4/16 = 1.4 l CH_4

CH_4 generation rate per unit of COD removed

1 g CH_4 ~ 4 g COD ~ 1.4 l CH_4

4 g COD ~ 1.4 l CH4

1 g COD ~ 1.4/4 = 0.35 l CH_4

or 1 kg COD ~ 0.35 m^3 CH_4 ----------- (3)

Complete anaerobic degradation of 1 kg COD produces 0.35 m^3 CH_4 at STP.

Source: Metcalf and Eddy, Wastewater Engineering Treatment and Reuse- 4th Edition, McGrow Hill Publishers