Jr. of Industrial Pollution Control 29(1)(2013) pp 121-126

www.envirobiotechjournals.com

UASB REACTOR PERFORMANCE EVALUATION BASED ON HEIGHT

ASHOK K. SHARMA[1], SARITA SHARMA[1], MANOJ HINGE [2] AND SHOURABH SINGH RAGHUWANSHI [1*]

[1] Department of Chemical Engineering, Ujjain Engineering, College, Ujjain, M.P., India
[2] Department of Chemical Engineering , Govt. Polytechnic, Ujjain, M.P., India

Key words : Anaerobic treatment, Upflow anaerobic sludge blanket reactor, COD, BOD.

(Received 31 July, 2012; accepted 5 September, 2012)

ABSTRACT

Height is an important feature of the UASB reactor. In a simple UASB reactor due to movement of methane in the upward direction, the activated sludge around it also moves in the upward direction, which increases the risk of losing the biomass. This can affect the performance of the UASB reactor. Keeping this fact in mind, we have to increase the height of the UASB reactor for getting the advantages of the gravitational force. This increase in height has some other effects also. In this paper we are determining the effect of the height on the performance of the reactor i. e., the effect on the percentage COD removal. From this research we found that UASB is showing plug flow type of behavior, shows axial conversion. We found that the COD removal decreases with the increasing height at HRT of 6.7 h.

INTRODUCTION

One of the most noticeable developments in anaerobic treatment process technology was the upflow anaerobic sludge blanket (UASB) reactor in the late 1970s in the Netherlands (Lettinga *et al.*, 1980). The UASB reactor is a reactor type that is frequently used in anaerobic water treatment. The reactor contains a sludge blanket which consists of anaerobic microorganisms in the form of pellets. These pellets are an essential characteristic of the UASB principle. The reactor is flowed through from the bottom to the top (CE 702, anerobic wastewater treatment).

The principle of UASB is the channeling of water from the bottom up to the top of the tank, process whilst forming a blanket of granular sludge and suspended in the tank. UASB is suitable for water with high BOD. Methane, a viable renewable energy, is a byproduct of this anaerobic treatment process (http://daiichiwaste.com/eng/upflow-anaerobic-eng.html). The granular sludge is the key factor of an efficiency of an UASB reactor (Vlyssidies *et al.*,2007). Sludge granules are at the core of UASB technology. A sludge granule is an aggregate of microorganisms forming during wastewater treatment in an environment with a constant upflow hydraulic regime. In the absence of any support matrix, the flow condition creates a selective environment in which only those microorganisms, capable of attaching to each other, survive and proliferates (Tchobanoglous *et al.*, 2003).

Importance of Height

The UASB reactor works best when desirable microorganisms are retained as highly active and fast

*** Corresponding Authors email :** shourabh.raghuwanshi@gmail.com;arshiakhan_2009@yahoo.in

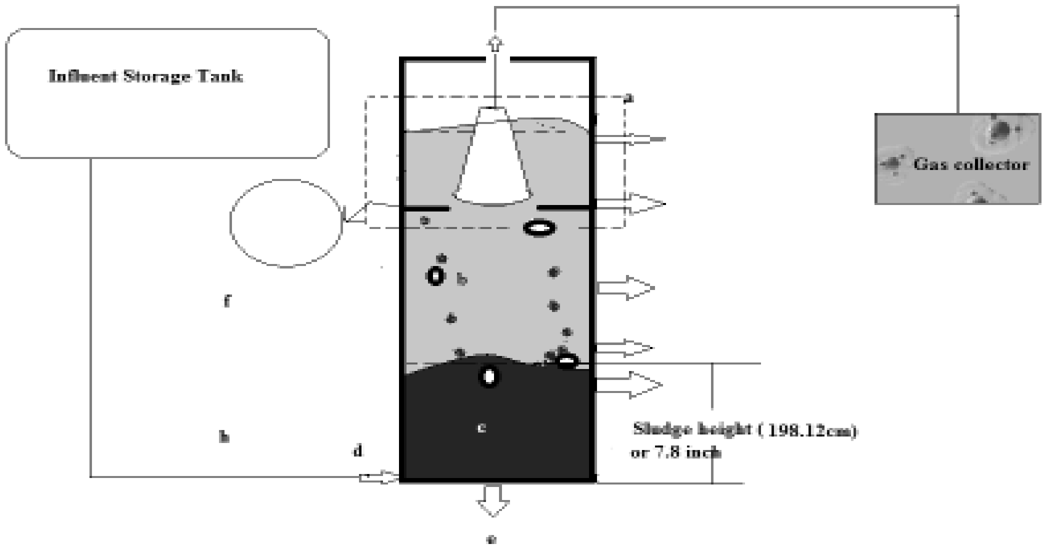

Fig. 1 Shows the Schematic diagram of reactor setup.

'a' is the gas-liquid-separator system ; 'b' is the gas bubble ; 'c' is the granular bed ; 'd' is the sludge inlet ; 'e' is the sludge outlet ; 'f' is the ring used as a flange

settling granules (NIIST, CSIR). To stop the removal of the sludge with the upflowing gas and wastewater we have to maintain the height of the reactor in such a manner, that it will support the G-L-S separator system to its best. And we utilize the natural phenomenon known as gravitational force for settling the particles. For this we require sufficient height.

MATERIALS AND METHODS

Wastewater from the dairy industry is generally produced in an intermittent way, and the flow and characteristics of wastewaters changes from one industry to another depending on the kind of systems and the methods of operation. The end of pipe effluent of the Sanchi Dairy (Ujjain Dugdh Sangh Maryadit, Ujjain, M.P., India), which is run by Madhya Pradesh State Cooperative Dairy Federation Ltd. and is located in South-East direction of Ujjain (Madhya Pradesh) city, situated 10 KM from the laboratory was used as influent in UASB. The general characteristics of the DWW which will became the feed for an anaerobic reactor, are given in Table 1.

Experimental setup

A pilot scale plant is constructed for meeting the main aim. The schematic diagram of the pilot scale UASB bioreactor is shown in Figure 1. The reactor was fabricated with an internal diameter of 15.24 cm and a

Table 1. Characteristic of the influent dairy wastewater

Parameter	Range
BOD (mg/L)	573-617
COD (mg/L)	638-691
Temperature(?C)	26-34
TS (mg/L)	.1698-.2305
pH	3-7.5
Alkalinity (mg/L)	249-482

height of 121.92 cm. The total volume of the reactor was 22.26 L. Funnel shaped gas separator was used to liberate the generated biogas from the effluent and then the gas was led to the gas collector. The gas tank is a small box. The liberated gas was frequently measured for a fixed container.

HRT and the gas volume were recorded with respect to time.

The UASB reactor was operated at an ambient temperature ({may-June} 36°C).

Wastewater Characteristic is synthetically maintained for the nearly equal to the wastewater from the Sanchi-dairy Ujjain, was used as en influent continuously. The feed was introduced from the bottom of the column. The effluent was collected from the top of the column in a 20 liter polyethylene. Table 2 shows the dimensions of the reactor.

The figure of the reactor is as shown in the Figure 2. Figure 2 showing the different sectors of the reactor

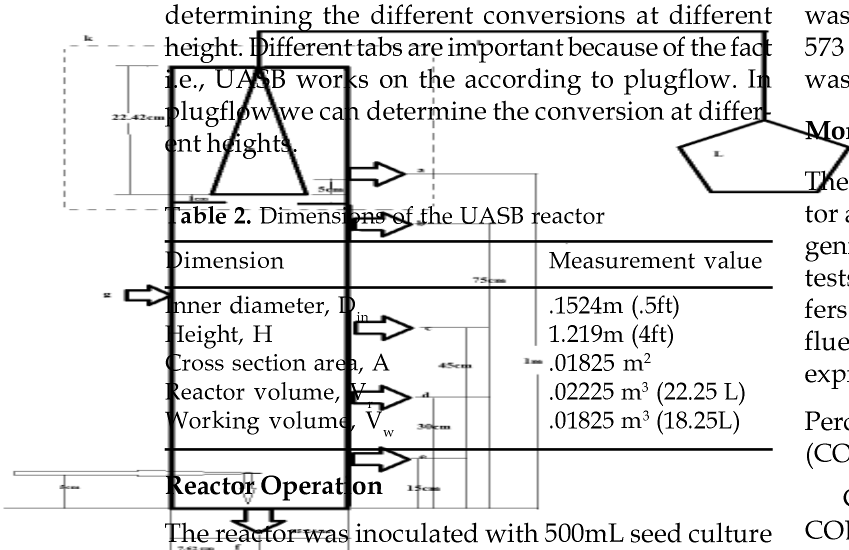

Fig. 2 Reactor with different segments and dimensions

a, b, c, d, and e are different outlets for effluent ; 'f' is the outlet for the granular bed or seed ; 'g' is the inlet for the granular bed or seed ; 'h' is the conical portion of the g-l-s system ; 'l' is the pipe line for the gas collector; 'L' is the gas collector ; 'i' is the inlet for the influent ; 'k' is the g-l-s system.

with their dimensions. Different tabs are provided for determining the different conversions at different height. Different tabs are important because of the fact i.e., UASB works on the according to plugflow. In plugflow we can determine the conversion at different heights.

Table 2. Dimensions of the UASB reactor

Dimension	Measurement value
Inner diameter, D_{in}	.1524m (.5ft)
Height, H	1.219m (4ft)
Cross section area, A	.01825 m^2
Reactor volume, V_r	.02225 m^3 (22.25 L)
Working volume, V_w	.01825 m^3 (18.25L)

Reactor Operation

The reactor was inoculated with 500mL seed culture contained anaerobic bacteria originated from the cowdunk which is predigested for about 45 days. In order to acclimate the sludge with Dairy wastewater, the reactor was fed with continuous flow of waste water (540-691 mg COD/L). For the days of operation, the bioreactor was continuously fed and maintained in normal pH by alkali addition. Continuous feeding the reactor was started with an initial organic loading rate.

1.2648 g/L.d COD (OLR) and HRT of 8.9 h. The HRT was maintained constant throughout the start-up period for duration of one day before the reading was taken. The influent COD concentration was about 573 and then it was stepwise increased. The reactor was continuously operated for 55 days.

Monitoring Efficiency

The man component to be removed in the UASB reactor are Suspended solids, organic matter and pathogenic organisms. For the first the TSS and COD-BOD tests are used. The removal of COD in the system refers to the difference between the influent and the effluent COD, hence the COD removal percentage is expressed by:

Percentage Removal of COD = [(CODin - CODout)/ (CODin)] *100

COD in and COD out representing the value of COD in influent and Effluent respectively and their difference shows that how much organic compounds are converted into organic acids, as a consequence the COD test will still present high values and the pH will lower (Pandya *et al.*, 2011).

Experiment

After 24 hours of the reactor startup, the samples were taken from the different taps which are available at the different distance in the reactor. Examination of the parameters of inlet and out was done regularly by the standard methods.

Fig. 3 Percentage COD Removal efficiency v/s different height at different days.

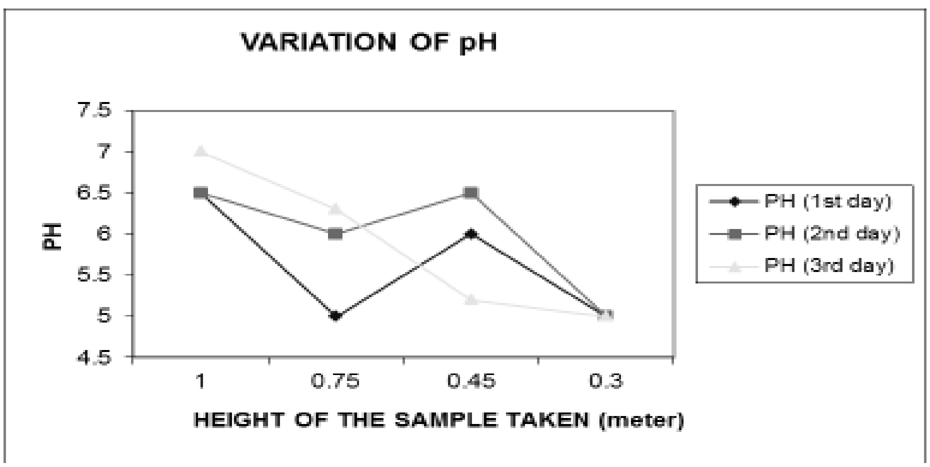

Fig. 4 pH v/s Different heights in different days

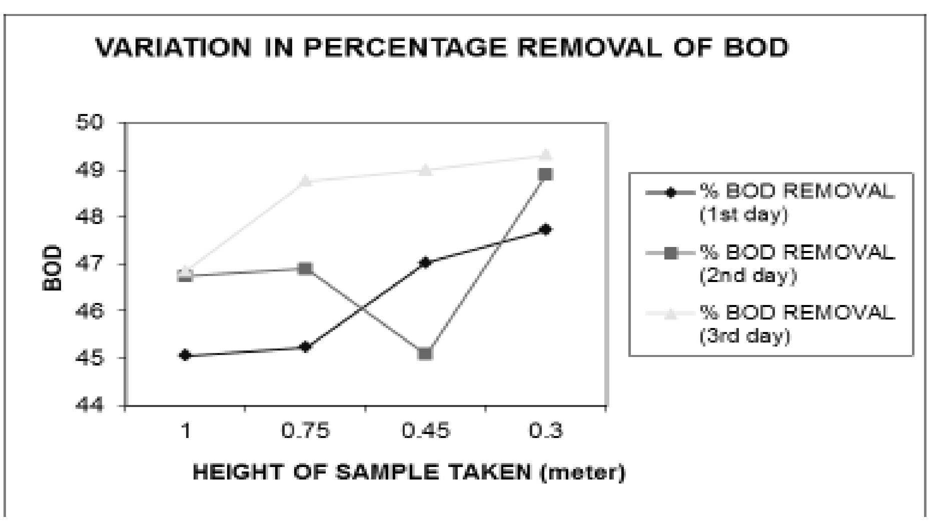

Fig. 5 Percentage removal efficiency of BOD in the UASB reactor

Table 6. Variation of TS W.R.T Height and Efficiency of G-L-S W.R.T Days

Day/hrs	1st Tap (mg/L)	2nd Tap (mg/L)	3rd Tap (mg/L)	4th Tap (mg/L)	Efficiency of G-L-S system (%) ([[4th tap-1st tap]/4th tap]*100)
1st/24	0.1113	0.1294	0.1383	0.1556	28.47
2nd/48	0.0798	0.1301	0.1304	0.1239	35.84
3rd/72	0.0937	0.1232	0.1374	0.2058	54.47

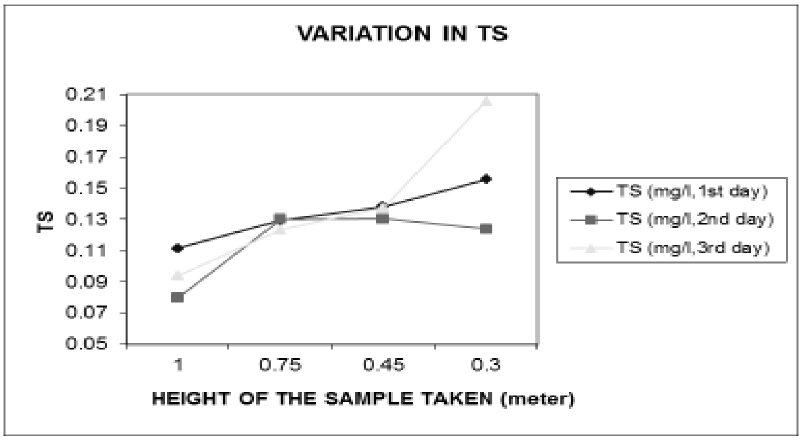

Fig. 6 Decrease in TS w.r.t height

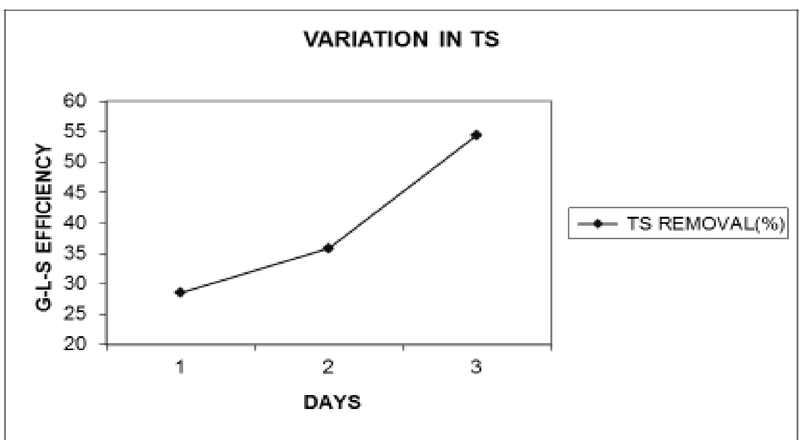

Fig. 7 G-L-S Efficiency w.r.t Days

The pH was maintained on the daily basis by adding an alkali (NaOH). The flow is very low as compared to the flow rate obtained by the design found in the Metcalf and Eddy, (1991) i.e., 86 L/h, therefore it is difficult to maintain the porosity of the bed, so we manually increase the flow rate of the reactor for few minutes to maintain the porosity of the bed.

RESULT AND DISCUSSIONS

Upflow Anaerobic Sludge Blanket Reactor Startup During the reactor startup period, the reactor was flowed with the influents (616 mg/L COD, pH 6-7 and HRT 8.9 hrs.) continuously. The first seed is the predigested cow dunk, kept for 45 days in the same condition as the reactor will work later. The parameters such as pH, COD, TS and TS of the influents and effluents were determined daily where the seed is cow dunk only .The COD removal, BOD and TS removal of the reactor could be determined. Table 3 shows the percentage Removal of COD.

Table 3. Percentage Removal of COD

Day	1st Tap	2nd Tap	3rd Tap	4th Tap
1st	48.86	50.95	52.07	52.01
2nd	51.20	50.54	53.63	54.47
3rd	51.54	54.13	54.62	55.27

Correlation of the COD removal with height startup period was plotted as in Figure 3.

The steady state condition was achieved after 45 days acclimatization during the preparation of the seed. Fig. 3 represents the percentage COD removal at various heights of different days. Different data obtained for the different height w.r.t pH is shown in Table 4. The correlation of the pH with height within startup period was plotted as in Figure 4.

Table 4. Variation of pH w.r.t height

Day/ hrs	1st Tap/ 1m	2nd Tap/ .75m	3rd Tab/ .45m	4thTap/ .30m
1st/24	6.5	5	6	5
2nd/48	6.5	6	6.5	5
3rd/72	7	6.3	5.2	5

The effluent pH presented the similar trend as the COD removal and the pH of the effluents varies from 6-7 in the steady state condition.

In these range of pH values, the process of acidogenesis was more dominant than methanogenesis. In the process of acidogenesis, biomolecules was hydrolyzed and fermented to produce acetate, hydrogen, carbon dioxide and propionate and butyrate. The propionate and butyrate were fermented further, to also produce hydrogen, carbon dioxide, and acetate as precursors for methanogenesis. The %BOD removal efficiency of the UASB reactor is as shown in the Table 5, and its graphical representation is shown in Figure 5.

Table 5. Percentage Removal of BOD with Cow dung

Day hrs	1st Tap	2nd Tap	3rd Tab	4thTap
1st/24	45.05	45.23	47.03	47.73
2nd/48	46.74	46.90	45.08	48.91
3rd/72	46.85	48.76	48.99	49.32

The TS removal within the startup period was also shown in table 6 and the range is plotted in Figure 6 and the G-L-S system efficiency is shown in the Figure 7.

Then, the steady state condition of the reactor could be defined. The TS and TSS removal showed the same trends within the startup period.

The UASB reactor was able to remove the TS and TSS at the steady state condition. Day by days we can observe that the efficiency of the G-L-S system is rising. The solids and particulate organic matters did not accumulated in the reactor but they were hydrolyzed and fermented into soluble form as no significant increment of sludge volume was observed.

CONCLUSION

The Conclusion that we can draw from this experiment is the decrease in the efficiency with the increasing height. This study shows that the efficiency of the anaerobic reactor say UASB depends on the height but in the reverse manner. Height is important because we do not want that the biomass leaves the UASB with the escaping methane and treated water. We can simply increase the efficiency of the Gas-Liquid-Solid separator system (G-L-S), so that the height can be kept as small as possible. Thus it would be concluded that -

1. The G-L-S system must show high effectiveness.
2. The height should be kept as small as possible.

REFERENCES

CE 702, Anaerobic wastewater treatment. Waste water treatment biological processes.

Lettinga, G., van Velsen, A.F.M., Hobma, S.W., de Zeeuw, W.J. and Klapwijk, A. 1980. Use of the upflow sludge blanket (USB) reactor concept for biological waste water treatment especially for anaerobic treatment. *Biotechnol Bioeng*....................?

Metcalf and Eddy, 1991. *Wastewater Engineering: Treatment, Disposal and Reuse*, 3rd edition New York: Mc Graw-Hill.

NIIST, CSIR, Thiruvananthapuram 695 019.

Modular UASB for Anaerobic treatment of soluble wastewater. ....?

Pandya, P., Ashok, K. Sharma, Sarita Sharma and Sanjay Verma, 2011. Anaerobic treatment of dairy industry waste water using an upflow anaerobic sludge blanket reactor. ....?

Tchobanoglous, G., Burton, F.L. and Stensel, H.D. 2003. Metcalf and Eddy Inc.- *Waste Water Engineering Treatment and Reuse*. Fourth Edition, Tata.

Vlyssides, A.G., Barampouti, E.M.P., Mai, S.T. and Tsimas, 2007. Size distribution of anaerobic granular sludge,

link:-1. http://daiichiwaste.com/eng/upflow-anaerobic-eng.html