Jr. of Industrial Pollution Control 29(1)(2013) pp 39-44
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PERFORMANCE EVALUATION AND DESIGN OF UASB REACTOR FOR TREATMENT OF DAIRY WASTE WATER WITH THE HELP OF MULTIPLE SEEDS

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

(Received 8 August, 2012; accepted 5 September, 2012)

ABSTRACT

UASB reactor is one of the most efficient reactors among the various bioreactors because it requires less "energy consumption" and less maintenance. It is highly energy efficient. It can consume more and more organic matter and the sludge remain is less as compared to that of the aerobic reactor, this is because of the fact that the catabolism activity in the methnogenic metabolism (anaerobic reaction) is greater than in aerobic metabolism. It produces methane during the reaction, which in turn can be utilized as a fuel. The problem that we have to face with the UASB reactor is the long startup time. It needs large startup time for the proper functioning of the reactor. If we add some pre-digested organic waste (which is rich in anaerobic microorganism) in the reactor, it will make our reaction much faster than before. Here we are testing the design of UASB on the basis performance (efficiency) of the reactor. During the experiment we found that for the influent 473.9mg/L - 513.0mg/L the COD reduces to 242.4mg/L - 248.6mg/L at the HRT of 6.7 h. As a result we found that the efficiency of the UASB increases from 51.5% to 71.2% for the same design of a reactor. Even the efficiency of the 'Mixed' seed for the granulation is 100% as compare to the cowdunk because it needs no time for granulation.

INTRODUCTION

Dairy products provide a critical source of nutrition and animal protein to millions of people in India. Singh *et al.*, (2011); Karmakar *et al.*, (2006).The dairy industry wastewaters are primarily generated from the cleaning and washing operations in the milk processing plants. It is estimated that about 2% of the total milk processed is wasted into drains (Munavalli and Saler, 2009).

Since dairy waste streams contain high concentrations of organic matter, these effluents may cause serious problems, in terms of organic load on the local municipal sewage treatment systems (Perle *et al.*, 1995). In addition to environmental problems that can result from discharge of dairy wastewaters, introduction of products such as milk solids into waste streams also represents a loss of valuable product for the dairy facilities (Baskaran *et al.*, 2003). All these contributes owards high biochemical oxygen demand (BOD) and

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nutrient contained in dairy wastewater, which are the main cause of the detoriation of the quantity of receiving water bodies (Tantrakarnapa , 2003).

Anaerobic method for the treatment of DWW is attracting the attention of researchers because of the presence of high organic content in the waste, low energy requirement of the process, lesser sludge production and generation of fuel in the form of methane. In one such attempt the efficiency of UASB reactor, has been studied. Also the possibility of employing a high-rate anaerobic process based on UASB reactor to generate some energy in the form of methane-rich biogas has been explored and some energy saved because UASB reactors do not need aeration and churning (which aerobic activated sludge process does). The UASB reactor was introduced by Lettinga and subsequently developed extensively by others. UASB reactor hold particular attraction because it can handle higher suspended solid loads and shock loads, besides wastewaters of a greater range of strengths, than other type of reactors (Pandya *et al*., 2011).

The key features of UASB that allows the use of high volumetric COD loading compared to other anaerobic process is the development of the dense granulated sludge (Liu *et al*., 2003).

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 islocated 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.

Table 1. Characteristic of the influent dairy wastewater

Parameter	Range
BOD (mg/L)	450-549
COD(mg/L)	473.9-686
Temperature (^{0}C)	26-34
TS (mg/L)	.1698-.2305
pH	3-7.5
Alkalinity (mg/L)	249-482

EXPERIMENTAL SETUP

A pilot scale plan 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 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).

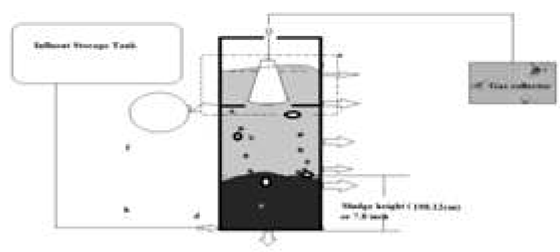


Fig. 1 Shows the schematic diagram of reactor setup.

'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

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 dimension of the reactor.

Design based on Tom: [http://www.google.co.in/imgres?imgurl=http://www. water and waste water .com/www_services/ask_tom_archive/images/uasb_fig_2.jpg&imgrefur]

We here used Volumetric flow rate as the basis of Calculation:-

Volumetric flow rate = ν^0 =30L/d

$=30 *10^{-3} m^3 /d$

Since, 1ft = 12inch=0.3048m

We have inner dia =6 inch

Therefore, inner dia, D =0.1524 m

$$\text{Cross-sectional area} = \frac{\pi}{4}D^2 = \frac{22}{7\times4}(0.1524)^2 = 0.01825\ m^2$$

$$velocity, v = \frac{v^0}{area} = \frac{30\times10^{-3}}{0.01825} = 1.644\ \text{m/s}$$

Hydraulic retention time, HRT = (Volume of liquid or working volume, V_w) (influent flow rate)

Working volume, V_w = cross-sectional * height of liquid
= 0.01825 * 1=0.01825 m^3

[Height of liquid = hight of 1st tap = 1m]

Therefore, HRT = (0.01825) ÷ (30*10^{-3})
= 2.708d =6.7 h = 6.7 h

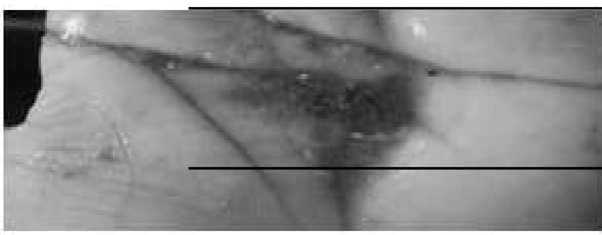
Volume of reactor
= cross sectional area * height of reactor

Hight of reactor = 4 ft = 4*.3048 m = 1.2192m

Therefore volume of reactor, V = .01825* 1.292
= 0.0222504 m^3
= 22.25 L

Table 2. Dimensions of the UASB reactor

Dimension	Measurement value
[illegible]	24m (0.5ft)
[illegible]	19m (4ft)
[illegible]	325 m^2
[illegible]	225 m^3 (22.25 L)
[illegible]	325 m^3 (18.25L)



First seed was prepared in a seeder of cylindrical shape quiet similar as an anaerobic sludge blanket reactor. The inoculum is pre-digested cow dunk (1.5kg), prepared with a flow rate of 30L/day (synthetic dairy wastewater having (20ml full-cream milk)/ (1 liter of water). The anaerobic fermentation of cow dunk has done for about 45 days. The composition of the raw dairy manure is presented in Table 1 (Wen *et al.*, 2004) (Demirer *et al.*, (2006-07), Cow dunk granules is as shown in the Fig. 2.

Fig. 2 Granules formed by cow dunk

Second seed is a mixture of black colored substance obtained from the drainage system of municipal wastewater used with the goat beats with this newly prepared manure and we call it as Mixed seed, as shown in the Fig. 3.

Fig. 3 Municipal black granules second ingredient of mixed seed.

Table 3. Composition of raw dairy manure (Wen *et al.*, 2004) Demirer *et al.*, (2006-07).

Dry matter (%)	14.60±0.25
Composition (% of dry matter)	
Neutral detergent fiber (NDF)	49.10±1.30
Acid detergent fiber (ADF)	37.83±.01
Acid detergent lignin (ADL)	11.24±.02
Hemicellulose (NDF–ADF)	11.27±0.90
Cellulose (ADF–ADL)	26.59±0.28
Lignin (ADL)	11.24±1.02
Total carbon	50.51±1.22
Total nitrogen	3.03±0.58

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 of COD = [(CODin -CODout)/(CODin)] *100 CODin and CODout 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. Examine of the parameters of inlet and out was done regularly by the standard methods.

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.

Data Collection and Result

Now we will compare the % removal of COD obtained from both the seeds for concluding one result based on the experiment. We take the % removal according to the different days. We will also have a look on the graphical representation of the comparison. Table 3 shows the Comparison between two.

With the help of the above data we can observe that, after adding the mixed seed the COD in the effluent gets reduced and hence the COD removal efficiency increases. The graph related to data is as shown in the Fig. 4.

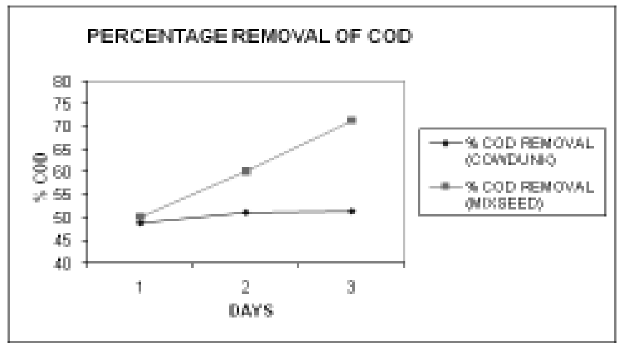


Fig. 4 COD Removal v/s Days.

The graph shows that we can change the removal Efficiency of the same reactor by changing the type of the seed. It also proves that, an easily available low cost seed can be used. This will help in managing the problem of granular formation plus the reaction will start as soon as possible which will reduce the time for the startup.

Table 4. Comparison between the two data of COD removal

Time	Cow Dunk			Mixed seed		
Days	Influent COD	Effluent COD mg/L	Percentage Removal	Influent COD	Effluent COD mg/L	Percentage Removal (Efficiency)
1st	473.9	242.4	48.86	663	330.6	50.14
2nd	493.7	241.0	51.2	674	268.7	60.13
3rd	513.0	248.6	51.5	686	197.3	71.24

Table 5. Comparison between the two data of BOD removal

Time	Cow Dunk			Mixed seed		
Days	Influent COD	Effluent COD mg/L	Percentage Removal	Influent COD	Effluent COD mg/L	Percentage Removal (Efficiency)
1st	450	247.27	45.05	491	268.92	45.23
2nd	447	238.0722	46.74	530	258.00	51.82
3rd	483.1	256.7145	56.85	549	223.72	59.25

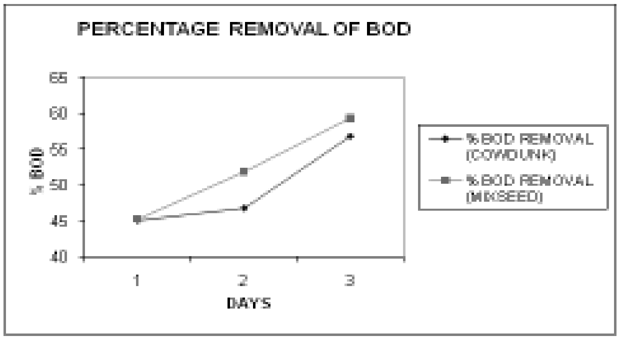


Fig. 5 BOD Removal v/s Days.

Now for BOD, pH and TS we can have a similar kind of tables. And they are as follows:

Table 6. Change in Effluent of pH

Time/ Days	Cow Dunk		Mixed seed	
Days	Influent	Effluent	Influent	Effluent
1st	7	6.5	7	5
2nd	7	6.5	7	3.9
3rd	7	7	7	4.2

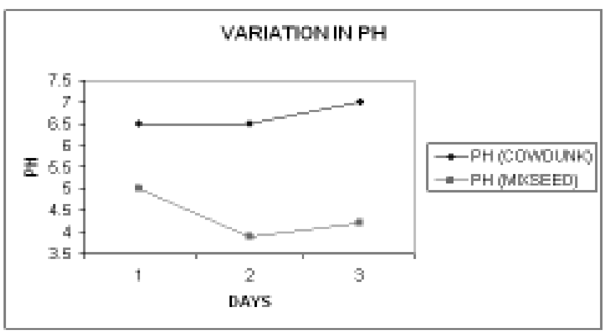


Fig. 6 pH v/s Days

Now let's look upon the effect of in pH values for both of the seed type:

Now we`ll look upon the chenges that can be seen in the TS during the the experiment in with the reactor for both of the seeds:

Whenever we have to increase the volumetric flowrate of the influent in the reactor, the sludgebed gets suspended and remain in suspension for app. 36hrs. During this period of 36hrs the bed slowly settles down due to the effect of the gravitational force. The settling of bed taks time because here we have used natural phenominon e.i., gravitational force . It also takes time due to the upflow of influent as-wel-as methane form the sludge bed.The data are as shown in the Table 7 and respective grafical representation in the Fig. 7.

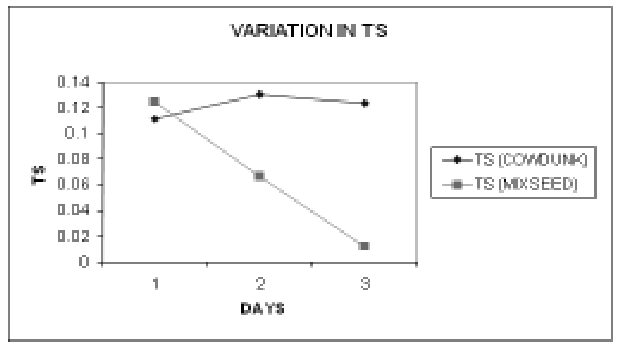


Fig. 7 TS v/s Days

CONCLUSIONS

Now we can conclude that the percentage recovery of COD is very-very greater in "Mixed" seed as compare to that from the "cow dunk" seed. This is may be due to the increase in the number of the microorganisms or due to the predigested condition of the sewage seed. In any biological process the workers are the microorganisms and if the number of microorganisms is increasing, the number of workers will increase which in turn increases the rate of the reaction.

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Table 7. Change in TS with respect to height

Time/ Days	Cow Dunk		Mixed seed	
Days	Influent (g)	Effluent (g)	Influent(g)	Effluent (g)
1st	0.0649	0.1113	0.1235	0.1237
2nd	0.0749	0.1301	0.1425	0.0657
3rd	0.0799	0.1232	0.1698	0.0115

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