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METHANE PRODUCTION FROM DISTILLERY WASTES IN ANAEROBIC CHARCOAL FILTERS

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Introduction

There are about 15 distilleries in Tamil Nadu spread over the entire State. The Industrial process adopted by the distilleries is almost same viz., fermenting the diluted Molasses with yeast and distilling the alcohol produced by passing a counter current of steam while allowing the fermented wash to come down a tall column. Only about 10 per cent molasses is utilised in the process and the major remaining part comes out as effluent in the process. The liquid wastes from the process mainly consist of spent wash besides yeast waste sludge and floor washings. Yeast waste sludge is separated out and dried on the nearby land and used as animal feed. Anaerobic lagoons or digestors are being suggested and tried out for treating distillery waste. In the anaerobic digestion, removal of organic matter results in generation and release of methane gas. One gram of Methane gas released equals 4 gms of biochemical oxygen demand satisfied. Recovery of methane gas also results in fuel recovery which can be used.

Previous Work Done at Kodungaiyur

Earlier studies conducted in this unit indicated that an admixture of carbon particles with spent wash resulted in copious methane gas production due to anaerobic activity. Hence it was planned to use charcoal pieces instead of broken stone in a specially fabricated anaerobic filter for treatment of distillery spent wash. Consequently studies were undertaken to explore the feasibility of anaerobic charcoal filter to treat distillery spent wash for methane recovery. This paper discusses methane recovery in the anaerobic charcoal filters on continuous loading resulting from these studies.

Materials and Methods

The spent wash used for the purpose of the study was obtained from a distillery unit at Chingleput and the characteristics of spent wash are given in Table I. Earlier studies at Kodungaiyur had shown that anaerobic ponds operating in series gave good performance in respect of removal of organic content though smell problems were noticed when the primary lagoon went sour. In the present studies two anaerobic charcoal filters were installed and the performance studied. Details of the filters are shown in Fig.1 and Fig.2.

Anaerobic Charcoal Filter I

This was essentially a downward flow reactor. This was 0.2 m dia cylindrical tank and of 1.52 m depth filled with charcoal pieces of size varying from 25 mm - 38 mm to a depth 0.90 m. The remaining portion was arranged such that influent could be admitted and effluent drawn out.

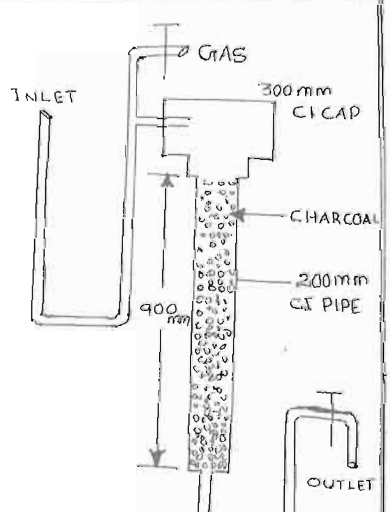

FIGURE 1
DOWN FLOW CHARCOAL ANAROBIC FILTER

Table I : Characteristics of Typical Spentwash from a distillery

	Characteristics	Average Value
1.	Colour	Dark Brown
2.	Odour	Molasses
3.	pH	3.5 - 4.0
4.	Total Solids	59000 mg/litre
5.	Volatile Solids	33000 mg/litre
6.	Total C.O.D (Dichromate Value)	84000 mg/litre
7.	Volatile Acids as acetic acid	1000 mg/litre

Anaerobic Charcoal Filter II

This was an upward flow reactor of 0.11 m dia cylindrical tank and of 1.2 m depth filled with charcoal of same size used in the downward flow reactor to a depth of 0.6 m from bottom. The inlet and outlet for the spent wash was similar to the first filter.

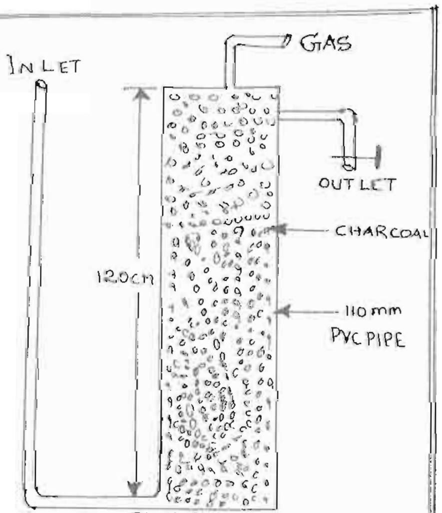

FIGURE 2
UPFLOW CHARCOAL ANAROBIC FILTER

In Filter I, spent wash was admitted from top and an equal quantity was withdrawn from the filter at the bottom. In Filter II the spent wash was admitted from bottom and the effluent was collected from top. In both the filters the gas was drawn from the top of filter and collected in the gas holder by water displacement system. Details of the gas collection chamber is shown in Fig.3.

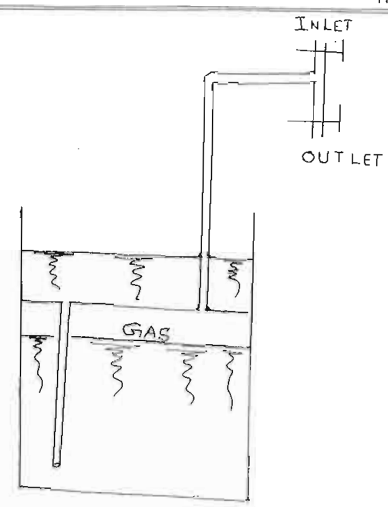

FIGURE 3
GAS STORAGE TANK

Initially both the filters were seeded with digested sludge from anaerobic pond treating sewage. Performance of the filters was observed for nearly one year and the results are shown in Table II. To commence with, in the downward flow reactor 1 litre of spent wash per day was introduced. The filters established themselves very quickly and it was found that they were giving effluent having a pH of 8.0 or more. Gas evolution was also fairly good. Since pH 7 is found to be optimum for production of gas, loading of spent wash was gradually increased. It was found that the pH was 7.5 when the loading was 2.5 - 3.5 litres per day for the downward flow reactor and 0.3 to 0.4 litres for upward flow reactor. At a loading 2.0 - 3.5 litres per day for downward flow and 0.25 to 0.4 litres per day of spent wash to upward flow reactor respectively, it was possible to maintain pH in the region 7.0-7.5. So this loading was taken as the normal and the experiment continued on that basis. It was found that the methane gas evolved readily from both reactors and had a tendency to build to a peak and then to reduce. In the upward flow reactor a steady increase of gas production as shown in graph was observed. The gas production in terms of volatile

Table II : GAS PRODUCTION IN CHARCOAL ANAEROBIC FILTERS

Sl. No.	Date	Downward flow filter: Volatile solids destroyed in mg/l	Downward flow filter: Quantity loaded in litres	Downward flow filter: Total V.S. destroyed in gms	Downward flow filter: Gas collected in litres	Upward flow filter: Volatile solids destroyed in mg/l	Upward flow filter: Quantity loaded in litres	Upward flow filter: Total volatile solids destroyed in gms	Upward flow filter: Gas collected in litres	pH D.F.	pH U.F.	Gas generated per kg of volatile solids destroyed in m^3 D.F.	Gas generated per kg of volatile solids destroyed in m^3 U.F.	Remarks
1.	28.8.78	21000	1.75	36.75	25.00	14950	0.2	2.99	6.0	8.0	8.0	0.680	2.007	
2.	14.9.78	16500	2.00	33.00	30.00	16700	0.2	3.34	5.0	8.0	8.0	0.909	1.497	
3.	11.10.78	12300	2.00	24.60	35.00	10500	0.2	2.10	5.5	7.5	7.5	1.425	2.619	
4.	18.10.78	12250	2.00	24.50	36.00	11750	0.2	2.35	5.5	7.5	7.0	1.460	2.340	
5.	8.11.78	6250	2.00	12.50	35.00	8750	0.2	1.75	5.7	7.5	7.5	2.800	3.257	
6.	27.11.78	12500	2.25	28.13	35.00	14750	0.25	3.69	5.7	7.5	7.5	1.244	1.545	
7.	5.12.78	12500	2.25	28.13	44.00	13500	0.25	3.38	5.2	7.5	7.0	1.564	1.538	
8.	21.12.78	13000	2.25	29.25	43.00	14000	0.25	3.50	5.7	7.5	7.0	1.470	1.629	
9.	4.1.79	11800	2.25	26.53	27.00	1300	0.25	3.27	8.0	7.5	7.5	1.017	2.447	
10.	20.1.79	11400	2.25	25.65	39.00	12900	0.25	3.23	9.0	7.5	7.5	1.520	2.386	
11.	13.2.79	12900	2.25	29.03	36.00	13900	0.25	3.48	9.0	7.5	7.0	1.240	2.586	
12.	20.2.79	13300	2.25	29.92	37.00	14300	0.25	3.58	9.15	7.5	7.5	1.236	2.559	
13.	12.3.79	12800	2.50	32.00	41.00	13500	0.30	4.05	9.00	7.5	7.5	1.281	2.222	
14.	20.3.79	14700	2.75	40.43	41.00	15400	0.30	4.62	9.10	7.5	7.5	1.014	1.963	
15.	11.4.79	12400	3.00	37.20	52.00	14300	0.30	4.29	9.10	7.5	7.5	1.398	2.335	
16.	17.4.79	12700	3.00	38.10	52.00	14700	0.30	4.41	9.50	7.5	7.5	1.364	2.200	
17.	6.5.79	13100	3.50	48.50	57.00	14500	0.30	4.35	8.70	7.5	7.5	1.175	2.000	
18.	15.5.79	12100	3.50	42.30	60.00	14500	0.40	5.80	8.10	7.5	7.5	1.418	1.307	
19.	6.6.79	10700	3.50	37.50	49.00	13000	0.40	5.20	7.10	8.0	7.5	1.307	1.366	

solids destroyed ranges from 1014 litres to 1564 litres/kg of volatile solids destroyed for the downward flow anaerobic charcoal filter and 1307 litres to 2963 litres/kg of volatile solids destroyed for upward flow reactor respectively. This quantity of gas is very high and how such an increase comes about has to be explained yet.

The detention period calculations are given below:

Calculation of Detention time in Charcoal Filter I

Diameter of Filter = 20 cm

Area of cross section = 314 cm^2

Depth of filter = 90 cm

Volume of filter = 28260 cm^3

Assume 50% void in charcoal

Volume of void = 14130 cm^3

= 14.13 litres

Volume loaded/day = 1.75 litres to 3.5 litres

Detention time = $\frac{14130}{1750}$ to

= $\frac{14130}{3500}$ days

= 8 days to 4 days

Detention time in charcoal filter II

Diameter of filter = 11 cm (outer diameter)

Assuming 5 mm wall thickness, inner diameter = 10 cm

Area of cross section = 79 cm^2

Depth of filter = 60 cm

Volume of filter = 79 x 60 cm^3

= 4740 cm^3

Assuming 50% void, volume of void

= 2370 cm^3

= 2.37 litres

Volume of spent wash loaded = .2 to .4 litre /day

Detention period = $\frac{2370}{200}$ to

= $\frac{2370}{400}$ days

= 12 days to 6 days

Discussions of Results

The gas production seems to be ensured in anaerobic charcoal filter in a small volume compared to 60 days detention time required for primary anaerobic ponds for distillery spent wash. For this particular set up the detention time was ranging from 4 to 8 days for downward flow and 6 to 12 days for upflow filters. Also the gas production was quite satisfactory and establishment of gas production was quick too. These are possible due to the following reasons.

i) Perhaps the filters operated as a complete mixing unit so that the micro organisms were spread uniformly, both in total mass and species. It was also possible to achieve uniform mixing of the feed at all times in all points of the filters due to this complete mixing pattern.

ii) Organic concentration of feed to the micro organisms at all times was kept constant in the reactors.

iii) The charcoal particles possess the adsorptive capacity which helps in adsorbing NH_4 ion concentration and consequent inhibition in digestion.

iv) The charcoal provides a surface for anaerobic micro organisms to establish themselves and thrive. Probably this resulted in prevention of upsets due to changes, in loading rate.

Further gas generation even when pH was 8 and more shows that volatile acids were present and were getting gassified. They were probably adsorbed by charcoal and released gradually for methane generation. Investigations are required to establish the parameters in respect of the variation in the quality of effluent, period of operation, and rate of gas evolution with reference to loading.

The gas generation for downward flow shows a maximum value of 1564 litres/kg of volatile solids destroyed for a loading rate of 2.25 litres/day. The value for upward flow is 2886 litres/kg of volatile solids destroyed at a loading rate of .25 litre/day. However, by volume the max. quantity is got for downward flow is 57 litres per day at the loading rate of 3.50 litres per day. It is 9.50 litres per day at the loading rate of .30 litres per day. Still higher loadings adversely affected both gas yield and rate of gas yield per kg of volatile solids destroyed. All these rates are high compared to the accepted rate of about 18 cubic feet of gas per pound of volatile solids destroyed (1300 litres/kg of volatile solids destroyed). As mentioned, a satisfactory explanation is yet to be formulated for the higher gas yield from anaerobic charcoal filters.

The B.O.D values for effluent from anaerobic charcoal filters could be done only in a few cases and hence not included here. The values were about those obtained by treating distillery spent wash in two anaerobic lagoons of 60 days and 40 days in series. This probably represents the maximum removable B.O.D by anaerobic digestion in both cases.

Summary and Conclusions

1. Use of charcoal in size indicated viz 25 mm - 38 mm is novel and due to its structure as well as its adsorption the charcoal anaerobic filter has shown a favourable methane production rate by permitting anaerobic organism to grow on its surface and also by adsorbing excess NH_4 ions which tend to be toxic in excess for anaerobic digestion.

2. Probably the adsorption helps in keeping the volatile acid concentration down so that even at higher loadings the pH was in the region of 7.0. At lower loadings, the pH was observed to be 8.0 and more which again may be due to adsorption of volatile acids. The volatile acids were probably slowly released for methane production by anaerobic microorganism.

3. The upward flow anaerobic filter gave nearly 50 per cent more gas which may be attributed to the better bacterial action due to the vertical upward flow of the anaerobic filter as against the downward flow anaerobic filter. The vertical flow probably results in better mixing and bacterial action.

4. Though the waste was very high in organic content and BOD, the detention period was low compared to the detention provided in anaerobic lagoons coming to $\frac{1}{10}$ of conventional requirement.

5. The gas yield was quite high both for downward flow and upward flow anaerobic charcoal filters. It was remarkably high for the upflow anaerobic charcoal filters. This is yet to be satisfactorily explained.

6. The arrangement was found easy to set up and gas generation was found to be quick.

7. The water displacement method for gas collection was also unique in that there was no moving gas dome.

8. Further studies are to be carried out for confirming and applying the findings in treating strong organic effluents effectively and with recovery of methane.

9. The B.O.D. of the effluent from the anaerobic charcoal filters compares favourably with the BOD of effluent from anaerobic lagoons in series. This means that all removable BOD is removed as efficiently in anaerobic charcoal filters.

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