

Biodegradation of Fat, Oil, and Grease by using an Upflow Anaerobic Sludge Blanket Reactor from Dairy Wastewater

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ABSTRACT: Biodegradation of fats, oil and grease (FOG) in dairy wastewaters has been a major challenge for the industry. Many treatment processes have been tried to solve the issue of environmental degradation caused by the wastewater effluents from the dairy industry. The Upflow Anaerobic Sludge Blanket Reactor (UASBR) has been suggested by several researchers with some success in the degradation of FOG. In this paper, a description of a modified UASBR with an enhanced surface area provision for bioactive sludge is described. It was found that the modified UASBR is efficient in terms of the reduction in FOG, COD, TDS, and VSS.

KEYWORDS: Fats, oil and grease, Upflow Anaerobic Sludge Blanket Reactor, Dairy wastewater, Effluent treatment, Bioactive sludge.

I. INTRODUCTION

Dairy processing units produce large quantities of effluents that are potentially harmful to the environment. There are varying standards in different parts of the world for liquid effluents that enter the environment from dairy processing units. However, meeting such standards is a challenge for process engineers owing to several reasons. Particularly in India, it is common to notice several violations of the set norms of effluents standards for dairy processing units [1]. The usual breaches of the standards result in obnoxious odour around the dairy processing units, excess of BOD and COD in the effluents, which is harmful for the biota living in the receiving ecosystems and potential harm to agricultural fields and resultant loss of health and livelihood for human beings. The degradation of fat, oil and grease has received considerable attention by researchers [2, 3, and 4].

In this paper, based on previous works [5, 6, and 7] the degradation of fat, oil and grease by an Upflow Anaerobic Sludge Blanket Reactor (UASBR) is described. This reactor improves the treatment efficiency of the dairy wastewater effluent in terms for Fat, oil and grease (FOG), COD, and BOD.

II. RELATED WORK

Gavala et al. (1999) emphasized the importance of anaerobic digestion in the treatment of dairy wastewater for the breakdown of the high fat content. They constructed an UASBR which was inoculated with anaerobic mixed liquor and looked at the changes in the COD. Long et al. (2008) have provided a detailed review of anaerobic co-digestion of fat, oil, and grease and described the process limitations of gas production. Tawfik et al. (2007) described the process of treatment of a combined dairy and domestic wastewater using activated sludge in an UASBR. Further, Brooksbank et al. (2006) have analysed the role of microbial degradation and modification of FOG.

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III. MATERIALS AND METHODS

III. A. INITIAL PARAMETERS

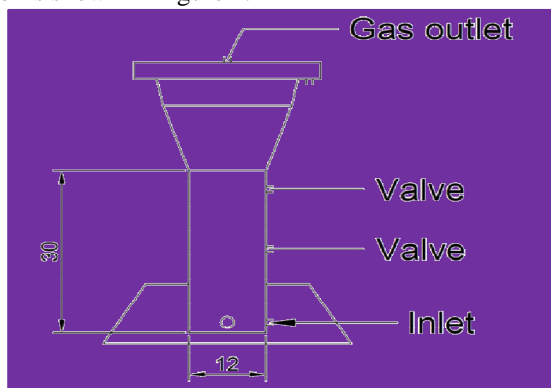
Effluent samples were collected from a dairy processing unit situated close to Chennai. Three samples of the dairy wastewater were collected from the collection tank before the bar screen chamber soon after it is released from the skimming process of the dairy unit. The characteristics of the wastewater are described in Table 1.

Table 1: The initial characteristics of the wastewater

S. No.	PARAMETERS	Minimum	Maximum
1	pH	5.63	6.47
2	TURBIDITY	123.7 NTU	151.7 NTU
3	ELECTRICAL CONDUCTIVITY (EC)	4.96 mmho/cm	5.74 mmho/cm
4	TOTAL SOLIDS	5650	6200
5	TEMPERATURE	26°C	28°C
6	TOTAL DISSOLVED SOLIDS	3000	3800
7	TOTAL SUSPENDED SOLIDS	2400	2950
8	VOLATILE SUSPENDED SOLIDS	340	420
9	FOG	63.2	162
10	TOTAL Phosphorous	57	81
11	BOD ₅	1060	1560
12	COD	1960	3300

III. B. OPERATING CONDITIONS OF UASB REACTOR:

The laboratory scale UASB reactor is shown in Figure 1.



All dimensions in cm.

Figure 1: Schematic diagram of the UASB reactor.

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The UASB reactor was operated at a flow rate of 1.2 ml/min by using a peristaltic pump for 24 h in a day for 70 days. 1.25 litres of the secondary sludge was added to the reactor prior to the inflow of the wastewater into the reactor. After 24 h of maintaining the secondary sludge in anaerobic conditions in the reactor, a synthetic mixture of wastewater (750 g of glucose + 250 g of sucrose) with a COD of 2000 mg/l was fed into the UASBR. Every 24 hours, a sample was drawn from the outlet of the UASBR to measure the changes in the COD level. This was used for the first 20 days. The primary sludge was maintained at anaerobic conditions for the development of microorganisms. Every 24 hours, a sample was drawn to analyse for changes in the COD levels, which would indicate the growth of microorganisms. However, no significant change in the COD level occurred for 7 days. Therefore, the reactor was emptied of secondary sludge and cleaned. Then 1.25 litres of primary sludge obtained from the dairy processing unit was introduced into the UASBR. As in the case of the secondary sludge, a synthetic mixture of wastewater (750 g of glucose +250 g of sucrose) with a COD of 2000 mg/l was fed into the UASBR. Every 24 hours, a sample was drawn from the outlet of the UASBR to measure the changes in the COD level. The changes in the COD level of the sample from the outlet of the UASBR was measured every 24 h for a period of 30 days. Once significant reduction of COD indicating the growth of microorganisms was observed, the synthetic wastewater inflow into the UASBR was stopped.

III. C. TREATMENT OF DAIRY WASTEWATER THROUGH THE UASBR

After the confirmation of the formation of the microorganisms in the reactor chamber within the matrix of the primary sludge, the dairy wastewater was introduced into the UASBR at the rate of 1.2 mg/min at a hydraulic retention time of 24 h. Every 24 h, a sample of the treated dairy wastewater was drawn from the UASBR and the FOG, COD, TDS and VSS were measured.

IV. RESULTS AND DISCUSSIONS

The results of the measured FOG, COD, TDS and VSS are tabulated in Table 2.

Table 2: The measurements of in the outlet samples of the FOG, COD, TDS, and VSS at different days.

Day	FOG mg/l	COD mg/l	TDS mg/l	VSS mg/l
1	158	2880	3120	416
2	158	2880	3114	416
3	157	2800	3110	411
4	158	2880	3003	407
5	153	2842	2763	402
6	155	2880	2772	396
7	155	2880	2772	397
8	152	2840	2763	394
9	148	2760	2672	391
10	145	2640	2519	387
11	146	2680	2511	384
12	145	2640	2489	379
13	142	2520	2376	375
14	143	2560	2364	371
15	140	2520	2329	366
16	136	2480	2261	362

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17	138	2520	2243	359
18	135	2440	2176	353
19	131	2400	2162	348
20	133	2440	2119	343
21	130	2360	2119	341
22	127	2320	2107	337
23	129	2360	2091	333
24	125	2280	2076	332
25	122	2200	2039	320
26	118	2120	1097	321
27	118	2120	1089	318
28	120	2160	1089	315
29	117	2120	1071	312
30	114	2080	1068	303
31	115	2080	1067	303
32	111	2000	1067	301
33	110	2000	1063	299
34	103	1880	1061	294
35	101	1800	1057	287
36	102	1760	1057	283
37	97	1680	1043	277
38	98	1720	1036	277
39	93	1640	1035	276
40	91	1600	1035	271
41	88	1560	1029	269
42	87	1560	1028	269
43	87	1560	1013	265
44	82	1480	1004	254
45	81	1440	998	251
46	76	1360	991	248
47	73	1320	983	243
48	72	1320	972	238
49	69	1200	956	224
50	67	1240	902	218
51	64	1160	861	215
52	61	1080	842	211
53	58	1000	836	204
54	55	920	781	203

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55	51	840	759	192
56	48	760	743	192
57	43	640	726	183
58	39	560	713	178
59	32	520	687	171
60	27	480	640	163
61	25	480	581	159
62	22	440	563	151
63	21	440	529	147
64	21	440	482	142
65	21	400	433	139
66	19	400	427	133
67	19	400	412	133
68	18	400	387	128
69	18	400	362	128
70	18	400	358	127

Figures 2, 3, 4, and 5 show the variations in FOG, COD, TDS, and VSS values on a 24-hr basis of the dairy wastewater treated through the constructed laboratory scale UASBR.

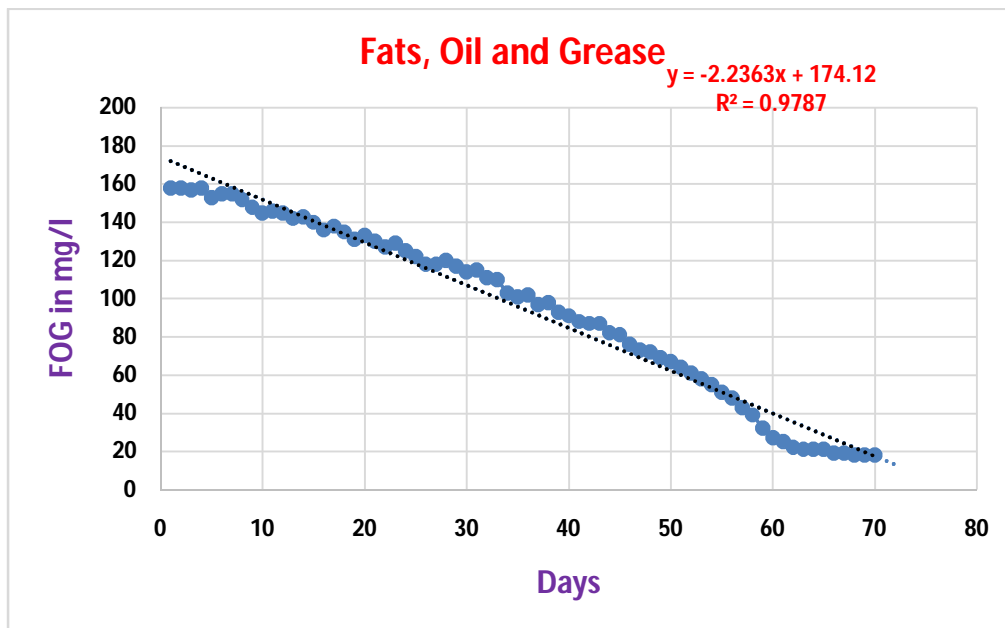


Figure 2: 24 h variation of FOG concentration for 1 to 70 days.

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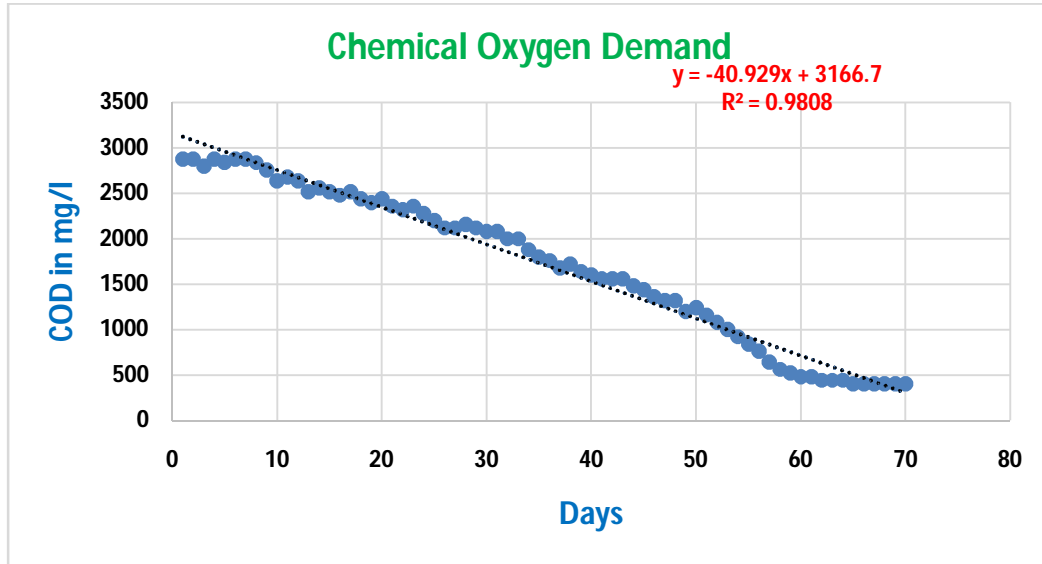


Figure 3: 24 h variation of COD concentration for 1 to 70 days.

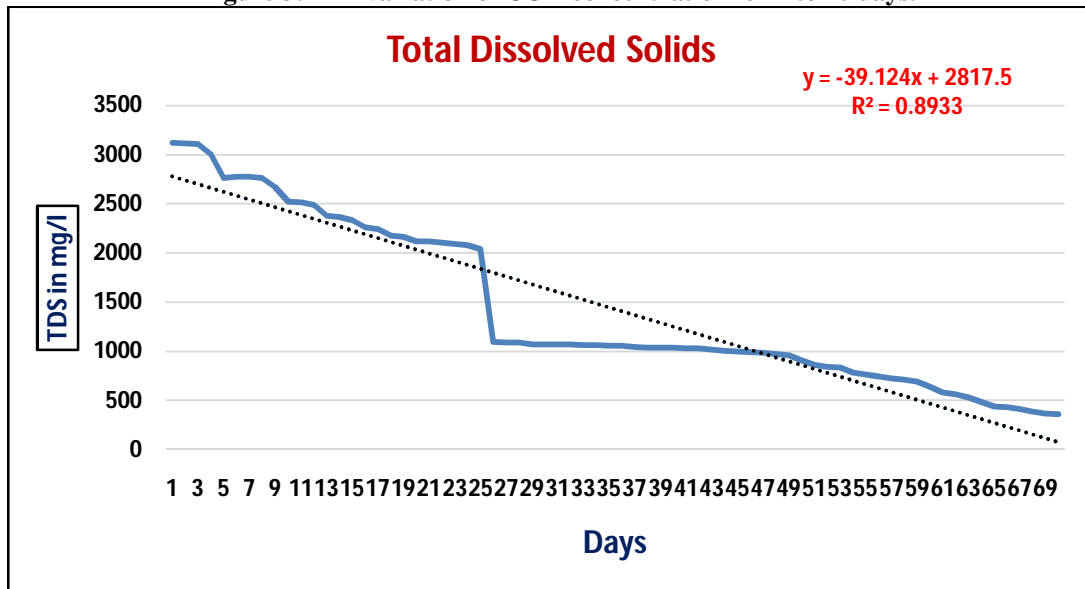


Figure 4: 24 h variation of TDS concentration for 1 to 70 days.

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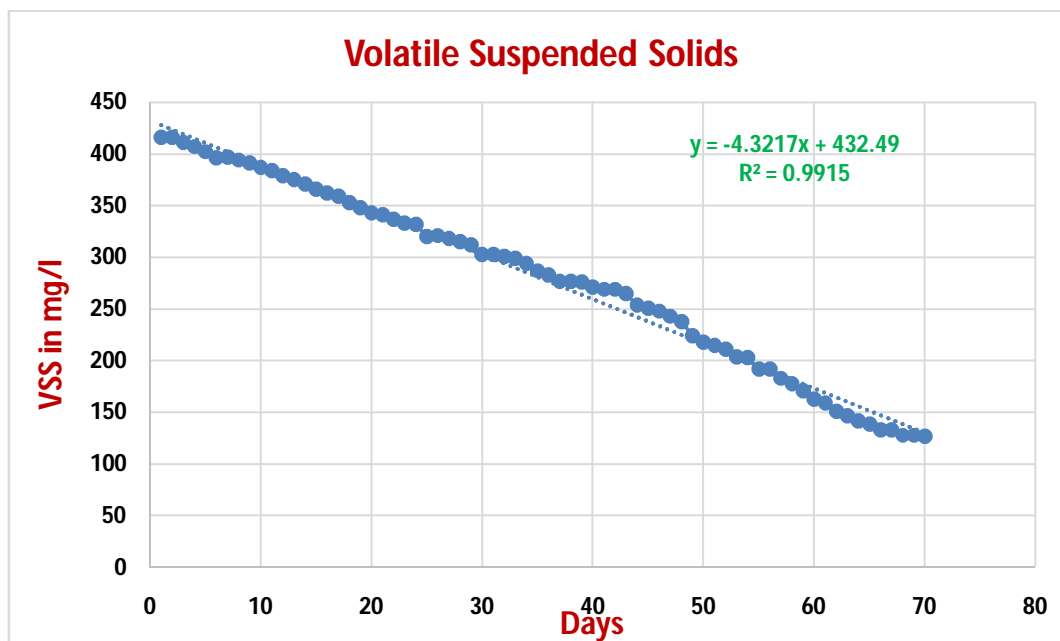


Figure 4: 24 h variation of VSS concentration for 1 to 70 days.

Figure 2 indicates that the FOG content linearly decreases with time owing to the increased growth of microorganisms with time. The linear regression model given in the figure for FOG has a confidence level of 98%.

Figure 3 indicates that the COD content linearly decreases with time owing to the increased growth of microorganisms with time. The linear regression model given in the figure for COD has a confidence level of 98%.

Figure 5 indicates that the VSS content linearly decreases with time owing to the increased growth of microorganisms with time. The linear regression model given in the figure for VSS has a confidence level of 99%.

However, as seen in Figure 4, except for TDS all the other three parameters show a decreasing trend with time for the entire period of 70 days. In the case of TDS, there is a sudden drop in the values at the 25th to 26th from 2039 mg/l to 1097 mg/l. This probably is due to an increase in the coagulation of suspended solid matter and the formation of granular sludge during this time in dairy wastewater. However, the exact reason for this phenomenon is not clear. This could be a subject for future studies. Overall, the laboratory scale UASBR with an increased sludge retention area that allows for a larger surface area of the sludge base has beneficial effects in terms of reduction of FOG, COD, TDS and VSS. This in particular is remarkable for the degradation of FOG.

V. CONCLUSIONS

- There is a significant decrease of FOG from 158 mg/l to 18 mg/l, which is caused by the increased sludge retention area and the resultant increase in the surface area of the sludge favouring enhanced microbial interaction.
- The COD levels are reduced linearly from 2880 mg/l to 440 mg/l over a period of 70 days.
- Similarly TDS reduces linearly from 3120 mg/l to 358 mg/l and the VSS from 416 mg/l to 127 mg/l during the

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70-day period. Overall, it can be concluded that the UASBR with a modified sludge retention area is efficient in the treatment of dairy wastewater.

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