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APPENDICES

Appendix A Experimental Data of Solubilization Study

Table A1 Enhanced-solubilization of hydrocarbons and the weight of Solubilized carbon to weight of surfactant ratio at 0.05% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	582	636	673	938	974	1,086	1,223	1,382	1,424	1,436
TOC of surfactant 0.05% w/v (mg/l)	328.9	328.9	328.9	328.9	328.9	328.9	328.9	328.9	328.9	328.9
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	62.8	72.2	82.3	98.3	108	110.7	113.0	113.3	113.4	122.8
Wt. of solubilized C to wt. of surfactant	0.1282	0.1473	0.1680	0.2006	0.2204	0.2259	0.2306	0.2312	0.2314	0.2506

Table A2 Enhanced-solubilization of hydrocarbons and the weight of solubilized carbon to weight of surfactant ratio at 0.10% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	1,948	2,105	2,424	3,138	3,217	3,347	3,472	3,557	3,621	3,631
TOC of surfactant 0.10% w/v (mg/l)	415.1	415.1	415.1	415.1	415.1	415.1	415.1	415.1	415.1	415.1
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	1,342.6	1,455.0	1,747.1	2,212.1	2,264.8	2,285.5	2,275.8	2,202.1	2,224.2	2,231.6
Wt. of solubilized C to wt. of surfactant	1.3700	1.4847	1.7828	2.2572	2.3110	2.3321	2.3222	2.2470	2.2696	2.2771

Table A3 Enhanced-solubilization of hydrocarbons and the weight of solubilized carbon to weight of surfactant ratio at 0.30% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	4,445	4,984	5,748	7,384	7,438	7,563	7,614	7,764	7,784	7,818
TOC of surfactant 0.30% w/v (mg/l)	1,163	1,163	1,163	1,163	1,163	1,163	1,163	1,163	1,163	1,163
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	3,091.7	3,586.1	4,323.2	5,710.2	5,737.9	5,753.6	5,669.9	5,661.2	5,639.3	5,670.7
Wt. of solubilized C to wt. of surfactant	1.0516	1.2198	1.4705	1.9422	1.9517	1.9570	1.9285	1.9256	1.9181	1.9288

Table A4 Enhanced-solubilization of hydrocarbons and the weight of solubilized carbon to weight of surfactant ratio at 0.50% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	5,384	6,441	7,351	10,243	10,487	10,683	10,983	11,045	11,064	11,093
TOC of surfactant 0.50% w/v (mg/l)	1,677	1,677	1,677	1,677	1,677	1,677	1,677	1,677	1,677	1,677
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	3,516.7	4,529.1	5,412.2	8,055.2	8,272.9	8,359.6	8,524.9	8,428.2	8,405.3	8,431.7
Wt. of solubilized C to wt. of surfactant	0.7177	0.9243	1.1045	1.6439	1.6883	1.7060	1.7398	1.7200	1.7154	1.7208

Table A5 Enhanced-solubilization of hydrocarbons and the weight of solubilized carbon to weight of surfactant ratio at 0.75% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	7,461	9,671	13,081	13,762	13,937	14,392	14,430	14,601	14,698	14,723
TOC of surfactant 0.75% w/v (mg/l)	2,074	2,074	2,074	2,074	2,074	2,074	2,074	2,074	2,074	2,074
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	5,196.7	7,362.1	10,745.2	11,177.2	11,325.9	11,671.6	11,574.9	11,587.2	11,642.3	11,664.7
Wt. of solubilized C to wt. of surfactant	0.7070	1.0016	1.4619	1.5207	1.5409	1.5880	1.5748	1.5765	1.5840	1.5870

Table A6 Enhanced-solubilization of hydrocarbons and the weight of solubilized carbon to weight of surfactant ratio at 1.00% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	10,621	11,540	14,725	14,917	15,803	16,102	16,243	16,491	16,512	16,913
TOC of surfactant 1.00% w/v (mg/l)	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	8,193.7	9,068.1	12,226.2	12,169.2	13,028.9	13,218.6	13,224.9	13,314.2	13,293.3	13,691.7
Wt. of solubilized C to wt. of surfactant	0.8361	0.9253	1.2476	1.2418	1.3295	1.3488	1.3495	1.3586	1.3565	1.3971

Table A7 Enhanced-solubilization of hydrocarbons and the weight of solubilized carbon to weight of surfactant ratio at 2.00% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	12,740	14,384	18,921	26,173	26,381	26,571	27,841	28,014	28,132	28,312
TOC of surfactant 2.00% w/v (mg/l)	2,391	2,391	2,391	2,391	2,391	2,391	2,391	2,391	2,391	2,391
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	10,158.7	11,758.1	16,268.2	23,271.2	23,452.9	23,533.6	24,668.9	24,683.2	24,759.3	24,936.7
Wt. of solubilized C to wt. of surfactant	0.5183	0.5999	0.8300	1.1873	1.1966	1.2007	1.2586	1.2593	1.2632	1.2723

Table A8 Enhanced-solubilization of hydrocarbons and the weight of solubilized carbon to weight of surfactant ratio at 3.00% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	14,361	14,980	19,530	28,860	29,130	29,330	30,680	31,730	32,840	32,850
TOC of surfactant 3.00% w/v (mg/l)	2,639	2,639	2,639	2,639	2,639	2,639	2,639	2,639	2,639	2,639
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	11,531.7	12,106.1	16,629.2	25,710.2	25,953.9	26,044.6	27,259.9	28,151.2	29,219.3	29,226.7
Wt. of solubilized C to wt. of surfactant	0.3922	0.4118	0.5656	0.8745	0.8828	0.8859	0.9272	0.9575	0.9939	0.9941

Table A9 Enhanced-solubilization of hydrocarbons and the weight of solubilized carbon to weight of surfactant ratio at 4.00% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	18,240	18,650	23,920	31,570	32,610	34,200	34,280	34,360	34,470	34,570
TOC of surfactant 4.00% w/v (mg/l)	2,853	2,853	2,853	2,853	2,853	2,853	2,853	2,853	2,853	2,853
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	15,196.7	15,562.1	20,805.2	28,206.2	29,219.9	30,700.6	30,645.9	30,567.2	30,635.3	30,732.7
Wt. of solubilized C to wt. of surfactant	0.3877	0.3970	0.5307	0.7195	0.7454	0.7832	0.7818	0.7798	0.7815	0.7840

Table A10 Enhanced-solubilization of hydrocarbons and the weight of solubilized carbon to weight of surfactant ratio at 5.00% w/v surfactant concentration

Parameter	Day									
	1	2	3	4	5	6	7	8	9	10
TOC of oil, surfactant, and water (mg/l)	21,800	24,162	28,951	35,421	36,633	37,682	38,162	38,412	38,673	39,760
TOC of surfactant 5.00% w/v (mg/l)	3,015	3,015	3,015	3,015	3,015	3,015	3,015	3,015	3,015	3,015
TOC of oil (mg/l)	190.3	234.9	261.8	510.8	537.1	646.4	781.1	939.8	981.7	984.3
Enhanced Solubilization (mg/l)	18,594.7	20,912.1	25,674.2	31,895.2	33,080.9	34,020.6	34,365.9	34,457.2	34,676.3	35,760.7
Wt. of solubilized C to wt. of surfactant	0.3795	0.4268	0.5240	0.6509	0.6751	0.6943	0.7013	0.7032	0.7077	0.7298

Appendix B Experimental Data of COD Removal

Table B1 Effluent COD and % COD removal at 10 kg COD/m^3d loading with influent COD of 22,000 mg/l

Day	Effluent COD (mg/l)	% COD removal
7	11,431	48.04
8	11,244	48.89
9	10,998	50.01
10	10,804	50.89
11	10,487	52.33
12	9,940	54.82
13	9,319	57.64
14	8,532	61.22
15	7,984	63.71
16	7,421	66.27
17	7,806	64.52
18	7,625	65.34
19	7,029	68.05
20	6,816	69.02
21	6,827	68.97
22	6,809	69.05
23	6,805	69.07
24	6,844	68.89
25	6,811	69.04
Last 5 days average	6,819	69.01

Table B2 Effluent COD and % COD removal at 20 kg COD/m^3d loading with influent COD of 22,000 mg/l

Day	Effluent COD (mg/l)	% COD removal
7	11,634	47.12
8	11,297	48.65
9	11,746	46.61
10	11,249	48.87
11	10,993	50.03
12	10,606	51.79
13	10,080	54.18
14	9,110	58.59
15	8,796	60.02
16	8,433	61.67
17	8,107	63.15
18	7,821	64.45
19	7,183	67.35
20	6,882	68.72
21	6,846	68.88
22	6,860	68.82
23	6,818	69.01
24	6,921	68.54
25	6,824	68.98
Last 5 days average	6,859	68.83

Table B3 Effluent COD and % COD removal at 30 kg COD/m^3d loading with influent COD of 22,000 mg/l

Day	Effluent COD (mg/l)	% COD removal
7	12,008	45.42
8	11,741	46.63
9	11,524	47.62
10	11,695	46.84
11	11,073	49.67
12	10,809	50.87
13	10,197	53.65
14	9,379	57.37
15	9,027	58.97
16	8,829	59.87
17	8,241	62.54
18	7,575	65.57
19	7,396	66.38
20	6,912	68.58
21	6,875	68.75
22	6,895	68.66
23	6,901	68.63
24	6,888	68.69
25	6,904	68.62
Last 5 days average	6,896	68.66

Table B4 Effluent COD and % COD removal at 40 kg COD/m^3d loading with influent COD of 22,000 mg/l

Day	Effluent COD (mg/l)	% COD removal
7	13,321	39.45
8	13,156	40.20
9	12,727	42.15
10	12,129	44.87
11	11,328	48.51
12	10,866	50.61
13	10,228	53.51
14	9,693	55.94
15	9,438	57.10
16	9,126	58.52
17	8,562	61.08
18	7,874	64.21
19	7,511	65.86
20	7,456	66.11
21	7,528	65.78
22	7,438	66.19
23	7,427	66.24
24	7,447	66.15
25	7,454	66.12
Last 5 days average	7,458	66.10

Table B5 Effluent COD and % COD removal at 60 kg COD/m^3d loading with influent COD of 22,000 mg/l

Day	Effluent COD (mg/l)	% COD removal
7	16,949	22.96
8	16,687	24.15
9	16,181	26.45
10	15,521	29.45
11	15,875	27.84
12	15,367	30.15
13	14,487	34.15
14	13,818	37.19
15	13,607	38.15
16	13,158	40.19
17	12,500	43.18
18	11,774	46.48
19	11,398	48.19
20	11,385	48.25
21	11,136	49.38
22	11,141	49.36
23	11,211	49.04
24	11,143	49.35
25	11,136	49.38
Last 5 days average	11,192	49.13

Table B6 Effluent COD and % COD removal at 80 kg COD/m^3d loading with influent COD of 22,000 mg/l

Day	Effluent COD (mg/l)	% COD removal
7	17,371	21.04
8	17,140	22.09
9	16,826	23.52
10	16,713	24.03
11	16,293	25.94
12	15,880	27.82
13	15,215	30.84
14	14,920	32.18
15	14,509	34.05
16	14,753	32.94
17	14,062	36.08
18	14,282	35.08
19	13,600	38.18
20	13,059	40.64
21	13,057	40.65
22	12,962	41.08
23	13,055	40.66
24	13,059	40.64
25	13,055	40.66
Last 5 days average	13,041	40.72

Table B7 Effluent COD and % COD removal at 20 kg COD/m^3d loading with influent COD of 22,000 mg/l and without surfactant

Day	Effluent COD (mg/l)	% COD removal
7	14, 628	33.51
8	14, 524	33.98
9	14, 494	34.12
10	14, 379	34.64
11	14, 370	34.68
12	14, 854	32.48
13	14, 093	35.94
14	13, 917	36.74
15	14, 150	35.68
16	13, 748	37.51
17	13, 387	39.15
18	13, 330	39.41
19	13, 077	40.56
20	12, 828	41.69
21	12, 969	41.05
22	12, 654	42.48
23	12, 507	43.15
24	12, 637	42.56
25	12, 619	42.64
Last 5 days average	12, 702	42.26

Appendix C Experimental Data of Oil Removal

Table C1 Effluent oil concentration and % oil removal at 10 kg COD/m^3d loading with influent Oil concentration of 2% v/v

Day	Effluent oil concentration (% v/v)	% Oil removal
7	0.3632	81.84
8	0.3564	82.18
9	0.3492	82.54
10	0.3380	83.10
11	0.3310	83.45
12	0.3298	83.51
13	0.3092	84.54
14	0.2838	85.81
15	0.2692	86.54
16	0.2822	85.89
17	0.2590	87.05
18	0.2396	88.02
19	0.2138	89.31
20	0.1956	90.22
21	0.1932	90.34
22	0.1964	90.18
23	0.2010	89.95
24	0.1948	90.26
25	0.1960	90.20
Last 5 days average	0.1962	90.19

Table C2 Effluent oil concentration and % oil removal at 20 kg COD/m^3d loading with influent oil concentration of 2% v/v

Day	Effluent oil concentration (% v/v)	% Oil removal
7	0.3720	81.40
8	0.3568	82.16
9	0.3508	82.46
10	0.3382	83.09
11	0.3098	84.51
12	0.3472	82.64
13	0.3066	84.67
14	0.2804	85.98
15	0.2832	85.84
16	0.2692	86.54
17	0.2596	87.02
18	0.2394	88.03
19	0.2328	88.36
20	0.2018	89.91
21	0.1998	90.01
22	0.2026	89.87
23	0.1996	90.02
24	0.2018	89.91
25	0.2020	89.90
Last 5 days average	0.1962	90.19

Table C3 Effluent oil concentration and % oil removal at 30 kg COD/m^3d loading with influent oil concentration of 2% v/v

Day	Effluent oil concentration (% v/v)	% Oil removal
7	0.3898	80.51
8	0.3866	80.67
9	0.3808	80.96
10	0.3670	81.65
11	0.3432	82.84
12	0.3212	83.94
13	0.3168	84.16
14	0.2838	85.81
15	0.2780	86.10
16	0.2908	85.46
17	0.2770	86.15
18	0.2472	87.64
19	0.2392	88.04
20	0.2212	88.94
21	0.2208	88.96
22	0.2218	88.91
23	0.2242	88.79
24	0.2196	89.02
25	0.2214	88.93
Last 5 days average	0.2215	88.93

Table C4 Effluent oil concentration and % oil removal at 40 kg COD/m^3d loading with influent oil concentration of 2% v/v

Day	Effluent oil concentration (% v/v)	% Oil removal
7	0.4030	79.85
8	0.3976	80.12
9	0.3892	80.54
10	0.3872	80.64
11	0.3790	81.05
12	0.3450	82.75
13	0.3212	83.94
14	0.2958	85.21
15	0.3150	84.25
16	0.2838	85.81
17	0.2758	86.21
18	0.2698	86.51
19	0.2732	86.34
20	0.2640	86.80
21	0.2618	86.91
22	0.2636	86.82
23	0.2652	86.74
24	0.2602	86.99
25	0.2632	86.84
Last 5 days average	0.2630	86.85

Table C5 Effluent oil concentration and % oil removal at 60 kg COD/m^3d loading with influent oil concentration of 2.0 % v/v

Day	Effluent oil concentration (% v/v)	% Oil removal
7	0.5232	73.84
8	0.4898	75.51
9	0.5078	74.61
10	0.4790	76.05
11	0.4332	78.34
12	0.4190	79.05
13	0.3898	80.51
14	0.3698	81.51
15	0.3790	81.05
16	0.3592	82.04
17	0.3298	83.51
18	0.3176	84.12
19	0.3218	83.91
20	0.3150	84.25
21	0.3110	84.45
22	0.3116	84.42
23	0.3072	84.64
24	0.2974	85.13
25	0.3092	84.54
Last 5 days average	0.3086	84.57

Table C6 Effluent oil concentration and % oil removal at 80 kg COD/m^3d loading with influent oil concentration of 2% v/v

Day	Effluent oil concentration (% v/v)	% Oil removal
7	0.5794	71.03
8	0.5590	72.05
9	0.5472	72.64
10	0.5584	72.08
11	0.5292	73.54
12	0.5222	73.89
13	0.5030	74.85
14	0.4990	75.05
15	0.5098	74.51
16	0.4832	75.84
17	0.4684	76.58
18	0.4492	77.54
19	0.4478	77.61
20	0.4330	78.35
21	0.4272	78.64
22	0.4132	79.34
23	0.4252	78.74
24	0.4178	79.11
25	0.4232	78.84
Last 5 days average	0.4233	78.84

Table C7 Effluent oil concentration and % oil removal at 20 kg COD/m^3d loading with influent oil concentration of 2% v/v and without surfactant

Day	Effluent oil concentration (% v/v)	% Oil removal
7	1.1788	41.06
8	1.1604	41.98
9	1.1488	42.56
10	1.0872	45.64
11	1.0624	46.88
12	1.0338	48.31
13	1.0070	49.65
14	0.9622	51.89
15	0.9466	52.67
16	0.9188	54.06
17	0.8992	55.04
18	0.8632	56.84
19	0.8470	57.65
20	0.8570	57.15
21	0.8276	58.62
22	0.8090	59.55
23	0.8210	58.95
24	0.7972	60.14
25	0.8072	59.64
Last 5 days average	0.8198	59.01

Appendix D Experimental Data of Biogas Production

Table D1 Biogas production rate and content with various COD loading rate

COD loading rate (kg COD/m^3d)	Biogas production rate (l/h)	Biogas content						H_2 production rate (l/h)	CH_4 production rate (l/h)	CO_2 production rate (l/h)
		(% v/v)			Peak Area					
		H_2	CH_4	CO_2	H_2	CH_4	CO_2			
10	1.3536	9.05	30.12	60.83	30,166	7,530	60,831	0.1225	0.4077	0.8234
20	1.4718	10.05	28.09	61.86	33,714	7,022	61,858	0.1479	0.4134	0.9105
30	1.4301	10.11	25.84	64.05	33,512	6,464	64,051	0.1446	0.3695	0.9160
40	1.414	8.28	20.03	71.69	27,614	5,007	71,659	0.1171	0.2832	1.0137
60	1.2043	7.75	17.52	74.73	25,833	4,381	74,732	0.0933	0.2110	0.9000
80	1.1806	6.60	14.88	78.52	22,021	3,719	78,518	0.0779	0.1757	0.9270
20 (without surfactant)	0.9615	9.88	27.62	62.50	32,934	6,895	63,541	0.0950	0.2656	0.6009

Appendix E Gas Chromatograph's Calibration Curves

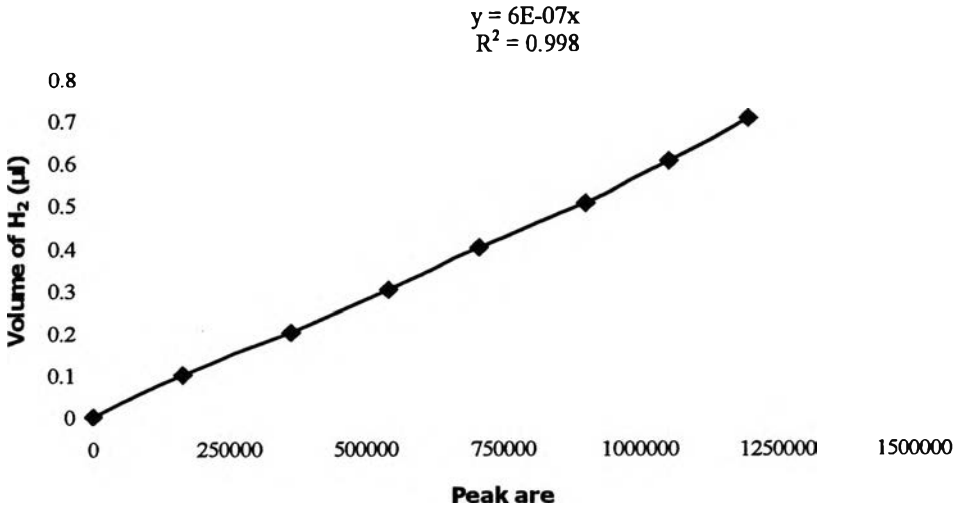
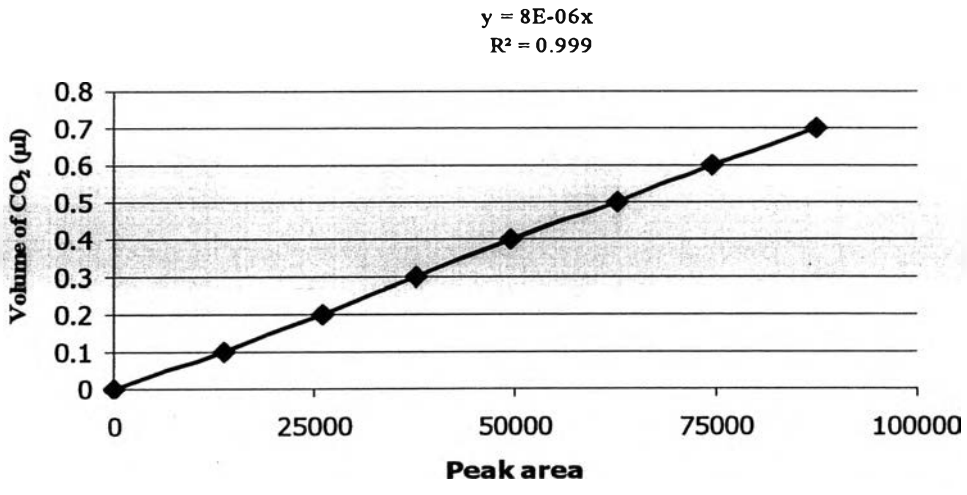


Figure E1 The relationship between peak area and volume of H_2.



ccc

Figure E2 The relationship between peak area and volume of CO_2.

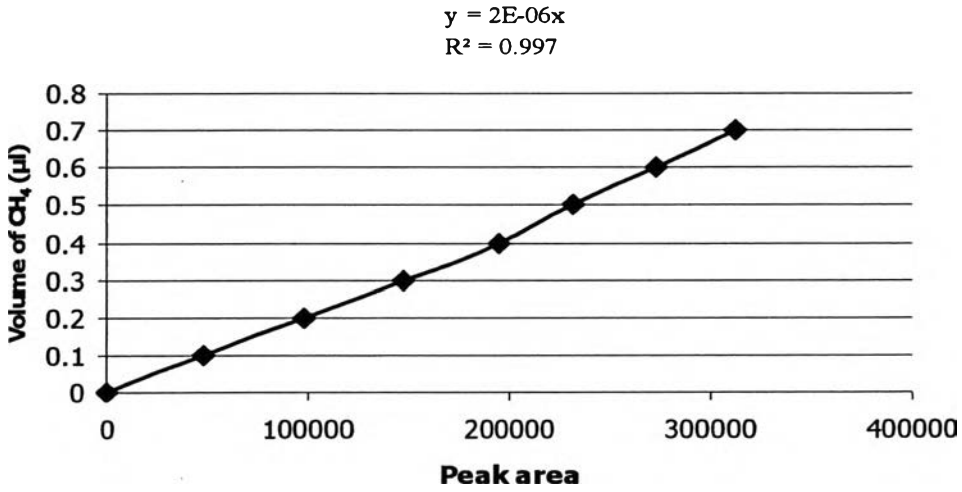


Figure E3 The relationship between peak area and volume of CH_4.

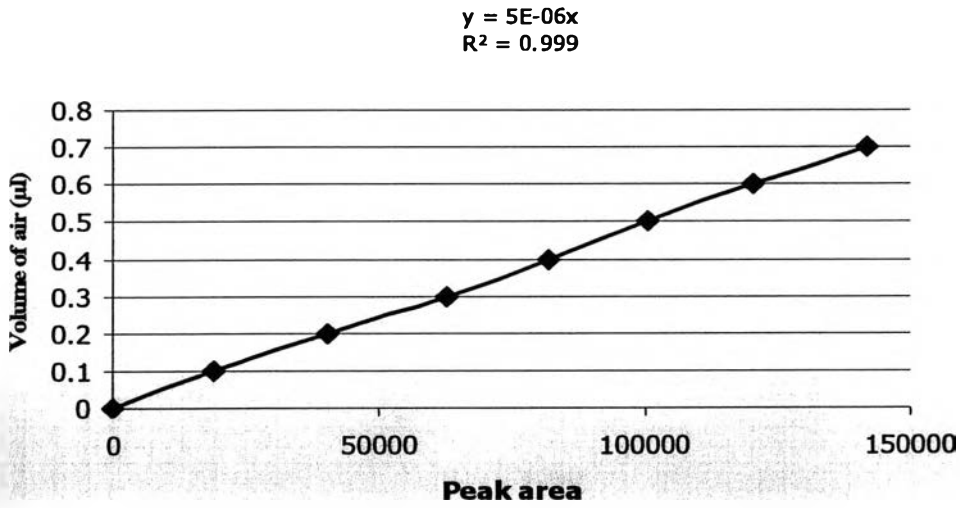


Figure E4 The relationship between peak area and volume of air.

Appendix F Experimental Data of Effluent pH

Table F1 Effluent pH at various COD loading rate and time

Day	pH						
	10 kg COD/m^3d loading	80 kg COD/m^3d loading	20 kg COD/m^3d loading	30 kg COD/m^3d loading	40 kg COD/m^3d loading	60 kg COD/m^3d loading	20 kg COD/m^3d loading (without surfactant)
1	6.04	5.89	6.06	5.93	5.85	5.97	6.06
2	6.02	5.81	5.70	5.64	5.61	5.76	5.70
3	5.91	5.74	5.54	5.45	5.52	5.62	5.54
4	5.78	5.71	5.25	5.14	5.53	5.40	5.25
5	5.67	5.64	5.18	5.10	5.02	5.31	5.18
6	5.61	5.59	5.15	5.04	4.99	5.34	5.15
7	5.57	5.60	5.09	4.91	4.82	5.28	5.09
8	5.52	5.61	5.04	4.83	4.62	5.15	5.04
9	5.47	5.57	4.97	4.86	4.63	5.17	4.97
10	5.48	5.46	4.96	4.74	4.56	5.09	4.96
11	5.41	5.37	4.94	4.64	4.54	4.91	4.94
12	5.38	5.31	4.93	4.69	4.51	4.81	4.93
13	5.36	5.28	4.95	4.51	4.59	4.83	4.95
14	5.37	5.29	4.97	4.58	4.50	4.72	4.97
15	5.32	5.18	4.88	4.55	4.49	4.68	4.88
16	5.26	5.16	4.85	4.52	4.44	4.71	4.85
17	5.28	5.12	4.81	4.57	4.47	4.68	4.81
18	5.19	5.10	4.79	4.50	4.38	4.68	4.79
19	5.15	5.09	4.79	4.48	4.36	4.65	4.79
20	5.16	5.07	4.80	4.47	4.33	4.60	4.80
21	5.12	5.11	4.81	4.45	4.31	4.68	4.81
22	5.13	5.06	4.80	4.45	4.29	4.67	4.80
23	5.14	5.10	4.79	4.47	4.30	4.65	4.79
24	5.12	5.09	4.79	4.48	4.26	4.71	4.79
25	5.11	5.07	4.78	4.47	4.27	4.69	4.78
Last 5 days average	5.13	5.08	4.80	4.47	4.29	4.67	4.80

Appendix G Determination of Volatile Fatty Acids as Acetic Acid by Distillation

Recovery Factor (f) Determination

- Distilling 150 ml of 0.0333 M (2,000 mg/l) of acetic acid (99.7 % purity) in distillation apparatus (volatile fatty acid is simulated by acetic acid)

- Calculate the recovery factor

$$f = \frac{a}{b}$$

where

a = volatile acid concentration recovered in distillate, mg/l

b = volatile acid concentration in standard solution used, mg/l

- Find volatile acid concentration recovered in distillate by titrating with 0.1 M of NaOH using phenolphthalein as an indicator (MW of acetic acid is 60.5 g/mol)

1) Volatile fatty acid in 50 ml of distillate equivalents with 11.7 ml of NaOH

Used NaOH = (11.7 ml) x (0.1 mol/l)

= 1.17×10^{-3} mol

Acetic acid in distillate = 1.17×10^{-3} mol

= (1.17×10^{-3} mol) x (60.5 g/mol)

= 0.07 g of acetic acid

Concentration of acetic acid in distillate

= (0.07 g of acetic acid)/(50 ml)

= 1.405×10^{-3} g/ml

= 1,405 mg/l

2) Volatile fatty acid in 25 ml of distillate equivalents with 5.7 ml of NaOH

Used NaOH = (5.7 ml) x (0.1 mol/l)

= 5.7×10^{-4} mol

Acetic acid in distillate = 5.7×10^{-4} mol

= $(5.7 \times 10^{-4}$ mol) x (60.5 g/mol)

= 0.034 g

Concentration of acetic acid in distillate

= (0.034 g of acetic acid)/(25 ml)

= 1.368×10^{-3} g /ml

= 1,368 mg/l

Average volatile acid concentration recovered in distillate = (1,405+1,368)/2

= 1,387 mg/l

Then volatile acid concentration recovered in distillate (a) = 1,387 mg/l

Volatile acid concentration in standard solution = 2,000 mg/l

Recovery factor (f) = (1,387 mg/l)/(2,000 mg/l)

= 0.6935

Determination of volatile fatty acids as acetic acid by distillation

From

$$\frac{\text{mg valitile acids as acetic acid}}{\text{L}} = \frac{\text{mL NaOH x N x 60,000}}{\text{mL sample x f}}$$

where

N = Normality of NaOH solution

f = recovery factor

At 20 kg/m^{3}d COD Loading Rate without surfactant at temperature of 37°C and uncontrolled pH, volatile fatty acid in distillate of 5 ml titrating equivalent with 5.5 ml of 0.1 M NaoH.

$$\frac{\text{mg volatile acids as acetic acid}}{\text{L}} = \frac{5.5 \times 0.1 \times 60{,}000}{5 \times 0.6935}$$

$$= 9{,}541 \quad \frac{\text{mg VFA as acetic acid}}{L}$$

Appendix H Experimental Data of VFA Concentration

Table H1 Effluent VFA concentration at various COD loading rate

COD loading rate (kg COD/m^3d)	VFA concentration (mg/l)
10	8,427
20	23,807
30	28,974
40	31,945
60	22,534
80	9,541
20 (without surfactant)	12,054

Appendix I Experimental Data of MLSS

Table I1 Final MLSS at various COD loading rate (started at 20 g/l of TSS)

COD loading rate (kg COD/m^3d)	MLSS (g/l)
10	42.62
20	87.34
30	79.61
40	61.42
60	52.75
80	49.71
20 (without surfactant)	51.46

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Proceedings:

1. Sema, T., Comchumpoo, K., Malakul, P., and Chavadej, S. (2007, December 20-22) Surfactant-enhanced biodegradation of crude oil sludge in an aerobic sequencing batch reactor (SBR): Effects of surfactant concentration, oil loading rate, and number of operation cycle per day. Proceedings of the 2007 International Conference on Engineering Research, Ho Chi Minh city, Vietnam.

Presentations:

1. Sema, T., Comchumpoo, K., Malakul, P., and Chavadej, S. (2007, December 20-22) Surfactant-enhanced biodegradation of crude oil sludge in an aerobic sequencing batch reactor (SBR): Effects of surfactant concentration, oil loading rate, and number of operation cycle per day. Paper presented at 2007 International Conference on Engineering Research, Ho Chi Minh city, Vietnam.