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APPENDICES

Appendix A Experimental Data of Enhanced Solubilization of Hydrocarbons In Oil sludge by Single and Mixed Surfactants.

1. Experiment Data of Effect of Contact Time on Solubilization of Oil Sludge by Single and Mixed Surfactants

Table A1 Effect of contact time on solubilization of oil sludge by SDS

Time (hr)	Total Organic Carbon (S+O) (ppm)			C from surfactant (ppm)	C from oil sludge (ppm)			average C from oil sludge (ppm)
	sample1	sample2	sample3		sample1	sample2	sample3	
control	39.8	39.7	40	0	39.8	39.7	40	39.83
0	11,090	11,097	11,103	10,987	103	92	116	103.67
2	12,280	12,265	12,276	12,130	150	135	146	143.67
6	12,492	12,405	12,465	12,182	310	223	283	272
12	12,574	12,582	12,526	12,262	312	320	264	298.66
20	12,853	12,796	12,798	12,311	524	485	487	498.70
28	12,980	12,889	12,985	12,390	590	499	595	561.33
48	13,002	13,006	13,010	12,442	560	564	568	564.00
70	13,030	13,035	13,028	12,469	561	566	559	562.00
93	13,156	13,164	13,172	12,639	517	525	533	525.00
120	13,230	13,225	13,229	12,696	534	529	533	532.00
150	13,390	13,394	13,389	12,850	540	544	539	541.00
154	13,396	13,399	13,387	12,853	543	546	534	541.00

C = Carbon

S = Nonionic surfactant

O = Oil sludge

Table A2 Effect of contact time on solubilization of oil sludge by Tween 80

Time (hr)	Total Organic Carbon (S+O) (ppm)			C from surfactant (ppm)	C from oil sludge (ppm)			average C from oil sludge (ppm)
	sample1	sample2	sample3		sample1	sample2	sample3	
control	39.8	39.7	40	0	39.8	39.7	40	39.83
0	11,090	11,097	11,103	10,987	103	92	116	103.67
2	12,280	12,265	12,276	12,130	150	135	146	143.67
6	12,492	12,405	12,465	12,182	310	223	283	272
12	12,574	12,582	12,526	12,262	312	320	264	298.66
20	12,853	12,796	12,798	12,311	524	485	487	498.70
28	12,980	12,889	12,985	12,390	590	499	595	561.33
48	13,002	13,006	13,010	12,442	560	564	568	564.00
70	13,030	13,035	13,028	12,469	561	566	559	562.00
93	13,156	13,164	13,172	12,639	517	525	533	525.00
120	13,230	13,225	13,229	12,696	534	529	533	532.00
150	13,390	13,394	13,389	12,850	540	544	539	541.00
154	13,396	13,399	13,387	12,853	543	546	534	541.00

Table A3 Effect of contact time on solubilization of oil sludge by mixed surfactants

Time (hr)	Total Organic Carbon (S+O) (ppm)			C from surfactant (ppm)	C from oil sludge (ppm)			average C from oil sludge (ppm)
	sample1	sample2	sample3		sample1	sample2	sample3	
control	39.8	39.7	40	0	39.8	39.7	40	39.8333333
0	13,478	13,480	13,481	13,242	236	238	239	237.6666667
2	13,713	13,715	13,720	13,323	390	392	397	393
6	13,983	13,980	13,979	13,375	608	605	604	605.6666667
12	14,806	14,804	14,801	13,465	1,341	1,339	1,336	1338.6666667
20	15,835	15,833	15,837	13,457	2,378	2,376	2,380	2378
28	18,017	18,015	18,020	13,467	4,550	4,548	4,553	4550.3333333
48	18,673	18,670	18,672	13,475	5,198	5,195	5,197	5196.6666667
70	18,677	18,678	18,673	13,485	5,192	5,193	5,188	5191
93	18,649	18,652	18,656	13,509	5,140	5,143	5,147	5143.3333333
120	18,672	18,670	18,669	13,522	5,150	5,148	5,147	5148.3333333
150	18,679	18,680	18,688	13,519	5,160	5,161	5,169	5163.3333333
154	18,682	18,681	18,687	13,521	5,161	5,160	5,166	5162.3333333

2. Experimental Data of Enhanced Solubilization of Hydrocarbons in Oil Sludge by Single and Mixed Surfactants

2.1 COD Method

Table A4 Enhanced solubilization of hydrocarbons in oil sludge by SDS at various concentrations

SDS Concentration		COD exerted by SDS (ppm)			Soluble COD by SDS+Oil (ppm)			COD by HC in aqueous phase (ppm)			average COD in aqueous phase (ppm)
%w/v	n x cmc	sample1	sample2	sample3	sample1	sample2	sample3	sample1	sample2	sample3	
control	control	0	0	0	112	115	114	113	115	114	114
0.1	4.13	1722.9	1782.32	1786.15	3872.23	3896.12	3913.52	2149.33	2113.8	2127.37	2130.17
0.5	20.66	10563	10496	10522	13547.32	13236.12	13026	2984.32	2740.12	2504	2742.81
1	41.32	22065.44	22043.02	22053.2	25045.63	24986.75	24995.23	2980.19	2943.73	2942.03	2955.32
2	82.64	39965.03	39956.71	39954.25	45632.91	45652.93	45690.15	5667.88	5696.22	5735.9	5700
3	123.97	53684.22	53693.01	53684.12	57952.32	57895.24	57876	4268.1	4202.23	4191.88	4220.74
4	165.29	85478.72	85645.23	85569.41	89458.26	89395.05	89378.56	3979.54	3749.82	3825.64	3851.67

Table A5 Enhanced solubilization of hydrocarbons in oil sludge by Tween 80 at various concentrations

Tw 80 Concentration		COD exerted by Tween80 (ppm)			Soluble COD by Tween80+Oil (ppm)			COD by HC in aqueous phase (ppm)			average COD in aqueous phase (ppm)
%w/v	n x cmc	sample1	sample2	sample3	sample1	sample2	sample3	sample1	sample2	sample3	
control	control	0	0	0	112	115	114	113	115	114	114
0.05	32	652.3	669.23	675.35	1,569.65	1,545.51	1,562.42	917.35	867.28	887.07	890.57
0.1	64	1,661.25	1,745.62	1,712.23	4,512.36	4,523.56	4,526.12	2,851.11	2,777.94	2,813.89	2,814.31
0.5	319	9,845	9,898	9,856.11	42.00	11,325.23	11,456.16	1,697	1,427.23	1,600.16	1,574.80
1	637	17,998	18,256	17,956	18,956.32	19,245.52	18,754.60	958.32	989.52	798.6	915.48
2	1,27432,684.12	32,659.45	32,674	33,658.20	33,711	33,685	974.08	1,051.55	1,011	1,012.21	
3	1,911	49,302	50,128.74	49,685.15	50,322.15	51,156.23	50,655.56	1,020.15	1,027.49	970.41	1,006.02
4	2,548	75,481	75,951.56	75,645.31	76,621.00	76,852.00	76,752.60	1140	900.44	1,107.29	1049.24

Table A6 Enhanced solubilization of hydrocarbons in oil sludge by mixed surfactants at various concentrations

Concentration		COD exerted by SDS (ppm)			Soluble COD by SDS+Oil (ppm)			COD by HC in aqueous phase (ppm)			average COD in aqueous phase (ppm)
SDS	Tw 80	sample1	sample2	sample3	sample1	sample2	sample3	sample1	sample2	sample3	
control	control	0	0	0	112	115	114	113	115	114	114
0.1	0.1	1,845.51	1,834.66	1,875.86	4,623.51	4,645.70	4,637.89	2778	2811.04	2762.03	2783.69
0.5	0.1	2,134.67	2,108.87	2,123.50	7,682.95	7,674.32	7,639.05	5548.28	5565.45	5515.55	5543.093333
1	0.1	11,643.43	11,678.22	11,632.18	17,425	17,435.83	17,453.91	5781.57	5757.61	5821.73	5786.97
2	0.1	22316.92	22354.19	22337	30,808.92	30,815.39	30,817.74	8492	8461.2	8480.74	8477.98
3	0.1	39996.78	40005.36	40010.65	47024.34	47053.61	47039.51	7027.56	7048.25	7028.86	7034.89
4	0.1	54820.45	54834.87	54816.78	61477.86	61483.09	61472.93	6657.41	6648.22	6656.15	6653.926667

2.2 TOC Analyzer

Table A7 Enhanced solubilization of hydrocarbons in oil sludge by SDS at various concentrations

SDS Concentration		Total Organic Carbon (S+O) ppm			C from Surfactant (S) ppm			C from Oil Sludge ppm			average C from oil sludge ppm
%w/v	n x cmc	sample1	sample2	sample3	sample1	sample2	sample3	sample1	sample2	sample3	
control	control	39.88	37.13	38.15	0	0	0	39.88	37.13	38.15	38.39
0.1	4.13	599	593.50	595.30	552.00	548.105	50.2	46.8	45.04	45.1	45.65
0.5	20.66	2,562	2,518.00	2,542.00	2,437.00	1,437.00	2440	125	81	102	102.67
1	41.32	5,371.00	5,155.00	5,284.00	4,966.00	4,866.00	4911	405	289	373	355.67
2	82.64	10,506.00	10,485.00	10,532.00	9963.2	9,940.50	10005.6	542.8	544.5	526.4	537.9
3	123.97	15,245.00	15,290.00	15,303.00	14,998.00	15,010.00	15032	247	280	271	266
4	165.29	20,070.00	19,690.00	19,872.00	19890	19,521	19674	180	169	198	182.33

Table A8 Enhanced solubilization of hydrocarbons in oil sludge by Tween 80 at various concentrations

Tw 80 Concentration		Total Organic Carbon (S+O) ppm			C from Surfactant (S) ppm			C from Oil Sludge ppm			Average C from oil sludge ppm
%w/v	n x cmc	sample1	sample2	sample3	sample1	sample2	sample3	sample1	sample2	sample3	
control	control	39.88	37.13	38.15	0	0	0	39.88	37.13	38.15	38.39
0.05	32	637.8	644.3	639.5	302.6	306.4	305.8	335.2	337.9	333.7	335.6
0.1	64	963.2	964.1	966.5	562.1	559.2	562.6	401.1	404.9	403.9	403.3
0.5	319	2,965.00	2,956.00	2,964	2,753.00	2,759.00	2,756.30	212	197	207.7	205.57
1	637	5,680.00	5,692.00	5,686.50	5,520.00	5,531.00	5,529.00	160	161	157.5	159.5
2	1,274	10,863.00	10,875.00	10871	10745.2	10752.6	10749	117.8	129.8	122	123.2
3	1,911	14,874.23	14,789.42	14,356.13	14,752.84	14,663	14,234.81	121.39	126.42	121.32	123.04
4	2,548	20562	20558.2	20563.8	20439	20446	20435.6	123	112.2	128.2	121.1

Table A9 Enhanced solubilization of hydrocarbons in oil sludge by Triton X-100 at various concentrations

Concentration		Total Organic Carbon (S+O) ppm			C from Surfactant (S) ppm			C from Oil Sludge ppm			average C from oil sludge ppm
SDS	Tw 80	sample1	sample2	sample3	sample1	sample2	sample3	sample1	sample2	sample3	
%w/v	n x cmc										
control	control	39.88	37.13	38.15	0	0	0	39.88	37.13	38.15	38.39
0.1	0.1	3,437	3,467.97	3,413.87	3,247.87	3,315.24	3,265.00	189.13	152.73	148.87	163.58
0.5	0.1	5,940	5,914.43	5,963.23	5,336.98	5,345.53	5,374.13	603.02	568.9	589.1	587.01
1	0.1	8,174.38	8,223.90	8,198.45	7,376.54	7,352.40	7,326.65	797.84	871.5	871.8	847.05
2	0.1	15,328.75	15,453.21	15,343.08	13,687.51	13,705.43	13,695.15	1,641.24	1,747.78	1,647.93	1678.98
3	0.1	11,754.54	11,764.16	11,698.56	10,842.52	10,742.00	10,776.32	912.02	1,022.16	922.24	952.14
4	0.1	9,985.55	9,896.76	9,937.75	9,390.89	9,407	9,413.42	594.47	489.76	524.33	536.19

Appendix B Experimental Data of Enhanced Biodegradation of Hydrocarbons in Oil Sludge by Single and Mixed Surfactants.

1. Surfactant Effects on Growth and TPH Degradation of Indigenous Bacteria

Table B1 The effect of oil sludge on growth and biodegradation of indigenous bacteria

day	TPH extract (mg)		TPH degradation (mg)		dry wt cell (mg)		Ave TPH degradation (mg)	Ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	980.32	981.44	0	0	0.984	0.973	0	0.9785
d1	970.91	971.68	9.41	9.76	10.321	11.719	9.585	11.02
d2	962.44	964.21	17.88	17.23	37.361	38.892	17.555	38.127
d3	958.03	957.24	22.29	24.2	41.229	40.618	23.245	40.618
d4	946.33	948.77	33.99	32.67	47.125	48.141	33.333	47.633
d5	895.51	897.26	84.81	84.18	50.857	50.644	84.495	50.75
d7	893.72	893.05	86.6	87.39	50.985	51.136	86.995	51.06

TPH = Total Petroleum hydrocarbons

Ave = average

Table B2 The effect of SDS at 2%w/v on growth and biodegradation of indigenous bacteria

day	TPH extract (mg)		TPH degradation (mg)		dry wt cell (mg)		Ave TPH degradation (mg)	Ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	986.43	987.75	0	0	0.264	0.312	0	0.288
d1	960.71	961.39	25.72	26.36	15.359	16.175	26.04	15.767
d2	894.17	895.44	92.26	92.31	40.127	39.729	92.285	39.928
d3	881.26	882.86	105.17	104.89	48.732	47.152	105.03	47.942
d4	739.34	740.13	247.09	247.62	51.647	52.721	247.355	52.18
d5	698.62	699.01	288.71	288.74	53	53.412	288.225	53.33
d7	697.82	698.53	288.61	289.22	53.932	52.285	288.915	53.11

Table B3 The effect of Tween 80 at 0.1 %w/v on growth and biodegradation of indigenous bacteria

day	TPH extract (mg)		TPH degradation (mg)		dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	981.89	982.34	0	0	0.312	0.371	0	0.342
d1	970.51	969.21	11.38	13.13	14.52	13.27	12.255	13.895
d2	831.69	835.27	150.2	147.07	44.21	45.731	148.635	44.971
d3	821.12	820.52	160.77	161.82	46.314	47.141	161.295	46.728
d4	782.46	784.73	199.43	197.61	53.871	53.974	198.52	53.923
d5	739.81	740.66	242.08	241.68	56.329	56.771	241.88	56.55
d7	738.37	739.25	243.52	243.09	56.532	56.723	243.305	56.628

Table B4 The effect of mixed surfactants on growth and biodegradation of indigenous bacteria

day	TPH extract (mg)		TPH degradation (mg)		dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample 1	sample 2	sample 1	sample 2	sample 1	sample 2		
control	985.29	988.48	0	0	0.117	0.139	0	0.128
d1	962.34	963.71	22.95	24.77	21.798	22.341	23.86	22.0695
d2	827.52	824.14	157.77	164.34	52.812	51.832	161.055	52.322
d3	802.79	800.63	182.5	187.85	56.671	57.835	185.175	57.253
d4	763.82	761.87	221.47	226.61	59.874	60.344	224.04	60.109
d5	658.43	653.32	326.86	335.16	61.783	60.218	331.01	61.0005
d7	648.36	650.49	336.93	337.99	61.585	61.898	337.46	61.7415

2. Surfactant Effects on Growth and TPH Degradation of *Pseudomonas aeruginosa*

Table B5 The effect of single and mixed surfactants on growth of *Pseudomonas aeruginosa* by using spectrophotometer

Days	Type of Surfactants		
	OD600 Tween 80 at 0.1%w/v	OD600 SDS at 2%w/v	OD600 Mixed Surfactants
d0	0.008	0.012	0.013
d1	0.009	0.013	0.0134
d2	0.0105	0.014	0.0135
d3	0.01055	0.0145	0.0143
d4	0.01056	0.0147	0.015
d5	0.01057	0.01475	0.0154
d6	0.01056	0.0148	0.0155
d7	0.01056	0.0148	0.0155

Table B6 The effect of oil, sludge on growth and biodegradation of *Pseudomonas aeruginosa*

day	TPH extract (mg)		TPH degradation (mg)		dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	980.32	981.44	0	0	0.984	0.973	0	0.9785
d1	962.52	964.71	17.8	16.73	19.39	20.45	17.265	19.92
d2	959.47	960.11	20.85	21.33	45.47	45.36	21.09	45.415
d3	947.29	948.46	33.03	32.98	50.05	50.84	33.005	50.445
d4	885.35	886.22	94.97	95.22	55.92	56.79	95.095	56.355
d5	883.72	883.01	96.6	98.43	58.31	58.42	97.515	58.365
d7	882.71	883.25	97.61	98.19	58.66	58.91	97.9	58.785

Table B7 The effect of SDS at 2%w/v on growth and biodegradation of *Pseudomonas aeruginosa*

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	986.43	987.75	0	0	0.264	0.312	0	0.288
d1	959.22	958.37	27.21	29.38	18.749	18.342	28.295	18.546
d2	892.72	891.52	93.71	96.23	42.349	41.871	94.97	42.11
d3	878.65	876.13	107.78	111.62	50.427	51.029	109.7	50.728
d4	737.26	736.24	249.17	251.51	53.923	54.074	250.34	52.281
d5	695.17	693.29	291.26	294.46	59.995	59.832	292.86	59.9135
d7	693.54	694.48	292.89	293.27	60.265	59.924	293.08	60.0945

Table B9 The effect of mixed surfactants on growth and biodegradation of *Pseudomonas aeruginosa*

day	TPH extract (mg)		TPH degradation (mg)		dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	985.29	988.48	0	0	0.117	0.139	0	0.128
d1	960.49	960.01	24.8	28.47	23.391	24.783	26.635	24.087
d2	823.24	820.17	162.05	168.31	55.822	54.424	165.18	55.123
d3	800.82	798.39	184.47	190.09	58.789	57.156	187.28	57.9725
d4	760.71	759.23	224.58	229.25	60.332	62.796	226.915	61.564
d5	656.58	659.05	328.71	329.43	62.229	63.486	329.07	62.8575
d7	657.32	659.91	327.97	328.57	62.347	63.587	328.27	62.967

Table B8 The effect of Tween 80 at 0.1%w/v on growth and biodegradation of *Pseudomonas aeruginosa*

day	TPH extract (mg)		TPH degradation (mg)		dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample 1	sample 2	sample 1	sample 2	sample 1	sample 2		
control	981.89	982.34	0	0	0.312	0.371	0	0.342
d1	969.42	968.71	12.47	13.63	16.73	17.34	13.05	17.035
d2	830.12	830.51	151.77	151.83	46.25	47.527	151.8	46.889
d3	793.82	792.31	188.07	190.03	50.378	51.242	189.05	50.81
d4	781.59	780.34	200.3	202	54.643	54.081	201.15	54.362
d5	707.74	708.45	274.15	273.89	59.854	60.542	274.02	60.198
d7	708.43	709.57	273.46	272.77	61.967	61.427	273.115	61.697

3. GC-MS

Table B10 TPH degradation of hydrocarbons by Indigenous bacteria (reported as type of hydrocarbons)

Type of Hydrocarbons	No surfactant	Mixed Surfactants	Tween 80 at 0.1%w/v	SDS at 2%w/v
2,4- Dimethylheptane	0.32	12.29	10.17	14.15
Phenanthrene	12.98	90.88	49.92	93.36
2- Methylphenanthrene	8.39	81.75	94.9	84.03
9,10- dimethylantracene	4.03	82.36	53.57	70.71
1- Methylantracene	3.21	64.43	43.39	48.34
4- Methylpyrene	3.17	24.77	39.16	40.09
1- Methylpyrene	7.15	85.09	30.79	56.24
5- Methylchrysene	0.47	48.64	21.52	35.64

Table B11 TPH degradation of hydrocarbons by *Pseudomonas aeruginosa* (reported as type of hydrocarbons)

Type of Hydrocarbons	No surfactant	Mixed Surfactants	Tween 80 at 0.1%w/v	SDS at 2%w/v
2,4- Dimethylheptane	0.61	12.94	12.62	15.67
Phenanthrene	16.83	92.17	88.36	94.42
2-Methylphenanthrene	8.47	87.43	96.62	86.72
9,10-Dimethlyanthracene	13.39	88.26	90.49	79.94
1-Methylantracene	5.47	102.29	84.82	44.12
4-Methylpyrene	12.26	37.15	62.32	46.71
1-Methylpyrene	13.71	92.21	63.04	60.02
5-Methylchrysene	1.17	61.74	36.91	37.79

Appendix C Experimental Data of Enhanced Biodegradation of Hydrocarbons in Bioreactor by Single and Mixed Surfactants.

1. Surfactant Effects on Growth and TPH Degradation of Indigenous Bacteria in Bioreactor

Table C1 The effect of oil sludge on growth and biodegradation of indigenous bacteria in bioreactor (control reactor)

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1120.87	1117.75	2.45	7.72	21.78	23.53	5.085	22.655
d2	1115.45	1113.64	7.87	11.83	29.65	27.73	9.85	28.69
d3	1110.06	1098.43	23.26	27.04	32.34	34.87	25.15	33.605
d4	1085.53	1085.02	37.79	40.45	44.65	43.54	39.12	44.095
d5	1075.75	1077.34	47.57	48.13	46.78	47.31	47.85	47.045
d6	1064.21	1060.29	59.11	65.18	49.07	49.65	62.145	49.36
d7	1040.98	1044.64	82.34	80.83	50.43	50.95	81.585	50.69
d8	1039.52	1039.43	83.8	86.04	50.65	50.74	84.92	50.695
d9	1039.07	1040.32	84.25	85.15	50.87	50.94	84.7	50.905
d10	1039.43	1040.06	83.89	85.41	50.45	50.23	84.65	50.34

TPH = Total Petroleum hydrocarbons

Ave = average

Table C2 The effect of mixed surfactants on growth and biodegradation of indigenous bacteria in reactor 1

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample 1	sample 2	sample 1	sample 2	sample 1	sample 2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1084.71	1085.39	38.61	40.08	32.237	32.564	39.345	32.4005
d2	936.51	935.14	186.81	190.33	55.429	56.821	188.57	56.125
d3	929.62	928.24	193.7	197.23	57.891	58.392	195.465	58.1415
d4	881.01	883.43	242.31	242.04	60.237	59.984	242.175	60.1105
d5	819.64	821.28	303.68	304.19	65.148	66.037	303.935	65.5925
d6	792.12	794.47	331.2	331	66.134	66.783	331.1	66.4585
d7	771.98	769.84	351.34	355.63	67.459	66.948	353.485	67.2035
d8	743.82	744.29	379.5	381.18	66.278	66.519	380.34	66.3985
d9	742.28	741.53	381.04	383.94	66.096	66.254	382.49	66.175
d10	742.72	741.46	380.6	384.01	65.909	66.018	382.305	65.9635

Table C3 The effect of mixed surfactants on growth and biodegradation of indigenous bacteria in reactor 2

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample 1	sample 2	sample 1	sample 2	sample 1	sample 2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1092.76	1090.24	30.56	35.23	28.582	28.387	32.895	28.4845
d2	943.64	941.59	179.68	183.88	50.834	50.627	181.78	50.7305
d3	931.12	929.31	192.2	196.16	51.945	51.875	194.18	51.91
d4	884.09	882.72	239.23	242.75	52.356	52.076	240.99	52.216
d5	825.61	824.42	297.71	301.05	58.876	58.627	299.38	58.7515
d6	799.85	797.35	323.47	328.12	59.856	59.845	325.795	59.8505
d7	783.39	782.11	339.93	343.36	58.897	58.739	341.645	58.818
d8	751.77	750.02	371.55	375.45	58.549	58.409	373.5	58.479
d9	749.58	748.97	373.74	376.5	58.315	58.652	375.12	58.4835
d10	749.23	749.41	374.09	376.06	58.187	57.906	375.075	58.0465

Table C4 The effect of mixed surfactants on growth and biodegradation of indigenous bacteria in reactor 3

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1099.27	1101.38	24.05	24.09	27.986	27.649	24.07	27.8175
d2	949.12	950.69	174.2	174.78	49.674	49.385	174.49	49.5295
d3	935.57	936.73	187.75	188.74	50.436	50.083	188.245	50.2595
d4	889.91	890.42	233.41	235.05	51.753	50.996	234.23	51.3745
d5	833.13	834.28	290.19	291.19	57.863	56.948	290.69	57.4055
d6	808.55	809.82	314.77	315.65	59.639	59.742	315.21	59.6905
d7	799.33	800.07	323.99	325.4	58.496	58.287	324.695	58.3915
d8	762.21	760.18	361.11	365.29	57.396	57.459	363.2	57.4275
d9	760.19	761.36	363.13	364.11	57.507	57.431	363.62	57.469
d10	761.98	760.09	361.34	365.38	57.056	57.116	363.36	57.086

Table C5 The effect of mixed surfactants on growth and biodegradation of indigenous bacteria in reactor 4

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1103.61	1104.82	19.71	20.65	27.457	27.684	20.18	27.5705
d2	951.73	952.25	171.59	173.22	46.861	47.832	172.405	47.3465
d3	937.13	938.86	186.19	186.61	48.993	49.934	186.4	49.4635
d4	890.58	888.45	232.74	237.02	49.872	50.967	234.88	50.4195
d5	836.67	837.33	286.65	288.14	56.967	56.327	287.395	56.647
d6	811.53	813.37	311.79	312.1	58.969	59.035	311.945	59.002
d7	802.29	801.71	321.03	323.76	57.954	56.986	322.395	57.47
d8	764.47	761.18	358.85	364.29	57.459	57.398	361.57	57.4285
d9	763.37	764.29	359.95	361.18	57.673	57.175	360.565	57.424
d10	764.49	763.02	358.83	362.45	57.529	57.309	360.64	57.419

Table C6 The effect of mixed surfactants on growth and biodegradation of indigenous bacteria in reactor 5

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample 1	sample 2	sample 1	sample 2	sample 1	sample 2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1089.75	1088.95	33.57	34.37	29.967	30.051	33.97	30.009
d2	943.18	944.16	180.14	179.16	48.885	49.913	179.65	49.399
d3	929.05	929.33	194.27	193.99	49.945	50.027	194.13	49.986
d4	882.93	881.03	240.39	242.29	50.763	51.142	241.34	50.9525
d5	830.67	830.32	292.65	293	58.989	58.675	292.825	58.832
d6	806.31	805.79	317.01	317.53	59.834	60.004	317.27	59.919
d7	788.56	788.72	334.76	334.6	59.578	59.173	334.68	59.3755
d8	762.87	759.48	360.45	363.84	59.053	59.189	362.145	59.121
d9	757.23	757.92	366.09	365.4	58.879	58.067	365.745	58.473
d10	757.56	756.94	365.76	366.38	58.617	58.241	366.07	58.429

2. Surfactant Effects on Growth and TPH Degradation of *Pseudomonas aeruginosa* in Bioreactor

Table C7 The effect of mixed surfactants on growth and biodegradation of *Pseudomonas aeruginosa* in reactor 1

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1077.93	1078.29	45.39	47.18	32.237	32.564	46.285	32.4005
d2	930.11	929.82	193.21	195.65	55.429	56.821	194.43	56.125
d3	926.21	928.84	197.11	196.63	57.891	58.392	196.87	58.1415
d4	874.53	873.72	248.79	251.75	60.237	59.984	250.27	60.1105
d5	817.47	818.53	305.85	306.94	65.148	66.037	306.395	65.5925
d6	784.92	783.35	338.4	342.12	66.134	66.783	340.26	66.4585
d7	766.43	767.69	356.89	357.78	67.459	66.948	357.335	67.2035
d8	732.28	731.43	91.04	394.07	66.278	66.519	392.555	66.3985
d9	731.18	732.25	392.14	393.22	66.096	66.254	392.68	66.175
d10	732.24	731.08	391.08	394.39	65.909	66.018	392.735	65.9635

Table C8 The effect of mixed surfactants on growth and biodegradation of *Pseudomonas aeruginosa* in reactor 2

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample 1	sample 2	sample 1	sample 2	sample 1	sample 2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1090.49	1088.84	32.83	36.63	30.495	31.095	34.73	30.795
d2	940.12	939.31	183.2	186.16	52.287	51.932	184.68	52.1095
d3	926.51	925.26	196.81	200.21	53.408	54.023	198.51	53.7155
d4	880.91	879.72	242.41	245.75	56.834	55.231	244.08	56.0325
d5	822.37	823.03	300.95	302.44	59.674	60.784	301.695	60.229
d6	796.65	797.74	326.67	327.73	62.785	62.815	327.2	62.8
d7	780.15	781.32	343.17	344.15	62.963	63.784	343.66	63.3735
d8	747.28	746.83	376.04	378.64	62.641	63.967	377.34	63.304
d9	746.84	747.73	376.48	377.74	62.494	62.765	377.11	62.6295
d10	747.21	746.63	376.11	378.84	62.198	62.371	377.475	62.2845

Table C9 The effect of mixed surfactants on growth and biodegradation of *Pseudomonas aeruginosa* in reactor 3

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1098.37	1097.87	24.95	27.6	28.354	28.176	26.275	28.265
d2	948.05	947.75	175.27	177.72	49.907	50.873	176.495	50.39
d3	931.48	930.21	191.84	195.26	50.623	51.498	193.55	51.0605
d4	886.57	885.32	236.75	240.15	51.419	50.926	238.45	51.1725
d5	831.27	832.49	292.05	292.98	57.923	56.387	292.515	57.155
d6	805.63	804.89	317.69	320.58	62.56	62.781	319.135	62.6705
d7	792.21	794.07	331.11	331.4	62.456	61.928	331.255	62.192
d8	761.14	761.52	362.18	363.95	61.785	61.039	363.065	61.412
d9	758.89	759.25	364.43	366.22	61.923	61.382	365.325	61.6525
d10	757.76	760.16	365.56	365.31	61.519	60.941	365.435	61.23

Table C10 The effect of mixed surfactants on growth and biodegradation of *Pseudomonas aeruginosa* in reactor 4

day	TPH extract (mg)		TPH degradation (mg)		Dry wt cell (mg)		ave TPH degradation (mg)	ave dry wt cell (mg)
	sample1	sample2	sample1	sample2	sample1	sample2		
control	1123.32	1125.47	0	0	0.583	0.561	0	0.572
d1	1100.2	1101.37	23.12	24.1	27.056	27.165	23.61	27.1105
d2	946.56	947.78	176.76	177.69	48.536	48.497	177.225	48.5165
d3	933.12	932.67	190.2	192.8	49.964	49.637	191.5	49.8005
d4	885.23	887.51	238.09	237.96	50.745	50.659	238.025	50.702
d5	833.93	834.45	289.39	291.02	57.216	56.953	290.205	57.0845
d6	809.36	807.22	313.96	318.25	58.965	58.216	316.105	58.5905
d7	789.88	799.96	324.44	325.51	58.437	58.051	324.975	58.244
d8	760.07	759.91	363.25	365.66	58.176	58.028	364.455	58.102
d9	758.63	758.86	364.69	366.61	57.993	57.839	365.65	57.916
d10	758.84	759.34	364.48	366.13	57.943	57.773	365.305	57.858

3. Total Organic Carbon (TOC) in Bioreactor

Table C11 Total Organic Carbon (TOC) of indigenous bacteria in bioreactor

Days	TOC Reactor1 (mg/l)			TOC Reactor2 (mg/l)			TOC Reactor3 (mg/l)			TOC Reactor4 (mg/l)			TOC Reactor5 (mg/l)	
	sample1		ave	sample1		ave	sample1		ave	sample1		ave	sample1	
	sample1	sample2		sample1	sample2		sample1	sample2		sample1	sample2		sample1	sample2
control	30.18	31.24	30.71	30.18	31.24	30.71	30.18	31.24	30.71	30.18	31.24	30.71	30.18	31.24
d0	678.09	680.67	679.38	669.86	673.81	671.835	672.57	680.36	676.465	669.95	680.43	675.19	687.28	684.39
d1	893.26	891.84	892.55	876.91	880.34	878.625	861.26	864.48	862.87	855.59	852.84	854.215	900.57	898.32
d2	1208.14	1219.45	1213.795	1201.27	1205.26	1203.265	1194.43	1197.61	1196.02	1189.67	1185.38	1187.525	1221.76	1220.54
d3	1523.37	1528.34	1525.855	1517.79	1514.86	1516.325	1502.27	1503.31	1502.79	1497.56	1493.16	1495.36	1534.43	1537.75
d4	2032.16	2034.85	2033.505	2025.54	2026.11	2025.825	2019.38	2020.05	2019.72	2017.76	2018.95	2018.355	2045.06	2046.76
d5	2153.09	2153.98	2153.535	2147.22	2145.36	2146.29	2032.07	2033.16	2032.62	2029.41	2028.04	2028.725	2156.85	2159.94
d6	2176.64	2177.07	2176.855	2161.74	2160.08	2160.91	2155.34	2156.47	2155.91	2134.29	2133.31	2133.8	2187.32	2186.47
d7	2214.58	2215.66	2215.12	2163.37	2164.43	2163.9	2157.74	2157.19	2157.47	2140.05	2140.97	2140.51	2214.47	2217.29
d8	2220.12	2220.36	2220.24	2164.88	2164.05	2164.465	2158.82	2159.95	2159.39	2145.52	2144.96	2145.24	2227.34	2228.74
d9	2219.94	2220.18	2220.06	2164.31	2165.17	2164.74	2159.07	2160.17	2159.62	2145.82	2144.87	2145.345	2228.02	2229.47
d10	2220.05	2221.14	2220.595	2164.72	2165.48	2165.1	2158.92	2158.06	2158.49	2145.01	2146.88	2145.945	2227.94	2228.15

Table C12 Total Organic Carbon (TOC) of *Pseudomonas aeruginosa* in bioreactor

Days	TOC Reactor1 (mg/l)		ave	TOC Reactor2 (mg/l)		ave	TOC Reactor3 (mg/l)		ave	TOC Reactor4 (mg/l)		ave
	sample1	sample2		sample1	sample2		sample1	sample2		sample1	sample2	
	control	30.18	31.24	30.71	30.18	31.24	30.71	30.18	31.24	30.71	30.18	31.24
d0	657.54	656.74	657.14	656.76	655.37	656.065	657.87	655.19	656.53	656.52	657.39	656.955
d1	892.39	891.43	891.91	870.82	871.16	870.99	863.57	864.17	863.87	859.32	860.08	859.7
d2	1211.45	1213.78	1212.615	1206.45	1203.97	1205.21	1198.42	1195.76	1197.09	1186.46	1188.15	1187.305
d3	1521.72	1523.34	1522.53	1515.98	1516.56	1516.27	1502.56	1505.31	1503.935	1497.29	1495.28	1496.285
d4	2034.47	2035.52	2034.995	2026.67	2026.86	2026.765	2016.37	2016.96	2016.665	2020.75	2021.16	2020.955
d5	2150.91	2152.96	2151.935	2145.34	2144.91	2145.125	2032.78	2031.67	2032.225	2039.44	2040.07	2039.755
d6	2179.42	2178.59	2179.005	2159.56	2160.17	2159.865	2139.15	2140.08	2139.615	2042.25	2041.93	2042.09
d7	2205.36	2206.74	2206.05	2158.27	2159.04	2158.655	2143.67	2143.24	2143.455	2044.71	2044.52	2044.615
d8	2211.17	2212.24	2211.705	2157.32	2157.65	2157.485	2146.29	2147.76	2147.025	2045.37	2044.96	2045.165
d9	2210.76	2212.76	2211.76	2157.89	2157.97	2157.93	2148.02	2147.58	2147.8	2045.64	2044.51	2045.075
d10	2211.2	2212.35	2211.775	2157.68	2157.69	2157.685	2147.13	2147.45	2147.29	2045.11	2044.85	2044.98

Appendix D Analytical Method.

1. Enhanced Solubilization

$$= (\text{Solubilization}_{\text{oil+surf}} - \text{Solubilization}_{\text{surf}}) - \text{Solubilization}_{\text{control}}$$

where Surf = Surfactant

2. % Enhanced Solubilization

$$= (\text{Enhanced solubilization} \times 100) / \text{Solubilization}_{\text{control}}$$

3. TPH Degradation

$$= \text{TPH}_{\text{control}} - \text{TPH}_d$$

where TPH = Total Petroleum Hydrocarbon

d = d1 to d7

4. % TPH Degradation

$$= (\text{TPH degradation} \times 100) / \text{TPH}_{\text{control}}$$

5. Yield of Bacteria

$$= \text{Dry weight cell} / \text{TPH degradation}$$

6. Rate of TPH Degradation

$$= \text{TPH degradation} / 7 \text{ days}$$

$$= \text{TPH degradation} / (7 \text{ days} \times \text{dry weight cell})$$

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