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APPENDICES

APPENDIX A

EXPERIMENTAL RESULT DATA

Table A-1 Temperature, pH and Sludge Volume Index

RUN No.	Temperature, pH, SVI				
	Temperature	pH - INF	pH-C	pH-S	SVI
	^{o}C	-	-	-	mℓ/g
1-1	31.7	7.65	7.50	7.50	108
1-2	31.2	7.70	7.51	7.52	65
1-3	29.6	7.85	7.40	7.41	-
2-1	31.0	7.30	7.49	7.25	137
2-2	31.4	7.45	7.60	7.10	-
3-1	31.0	7.80	7.90	7.45	164
3-2	31.0	7.80	7.98	7.50	164
4-1	31.0	7.65	7.96	7.85	128
4-2	32.0	7.66	7.95	7.83	111
5-1	31.5	7.25	7.52	7.50	120
5-2	31.0	7.35	7.70	7.50	120
6-1	31.0	7.48	7.65	7.65	95
6-2	31.0	7.80	7.60	6.80	66
6-3	30.2	6.85	7.71	7.51	44
6-4	31.2	7.45	7.70	7.53	50
7-1	30.8	5.00	7.40	7.28	50
8-1	31.4	6.28	7.90	7.40	56
9-1	29.5	7.30	7.35	7.25	229
9-2	31.0	7.40	7.40	7.25	249
9-3	29.5	7.55	7.80	7.60	174
9-4	30.0	7.62	7.70	7.60	187
9-5	31.2	7.60	7.40	6.20	170
9-6	30.5	7.65	7.30	6.20	-
9-7	30.2	7.30	7.00	5.46	79
9-8	30.4	7.50	7.00	6.10	54

Table A-1 Temperature, pH and Sludge Volume Index (Cont'd)

RUN No.	Temperature, pH, SVI				
	Temperature	pH-INF	pH-C	pH-S	SVI
	^{o}C	-	-	-	mℓ/g
10-1	30.2	7.55	7.35	5.68	38
10-2	29.5	7.80	7.75	7.75	34
11-1	29.8	7.75	7.85	6.78	44
11-2	28.5	7.88	7.91	6.50	44
12-1	29.5	7.30	8.08	7.62	52
12-2	29.2	7.35	7.98	7.69	52
13-1	30.0	7.30	8.10	7.70	69
14-1	30.3	7.00	7.70	7.70	57
15-1	28.8	7.40	7.84	8.00	133
15-2	28.5	7.56	8.02	8.10	107
16-1	29.7	7.59	7.90	7.74	246
16-2	29.6	7.55	8.00	7.78	-
17-1	28.5	7.50	7.80	7.45	150
17-2	27.1	7.50	7.90	7.30	155
18-1	27.5	7.16	8.15	7.60	97
18-2	27.5	7.40	8.00	7.55	89
19-1	29.2	7.35	8.10	7.50	-
20-1	28.0	7.70	7.70	7.75	375
20-2	27.5	7.40	7.98	7.88	983
20-3	27.6	7.40	7.95	7.85	577
21-1	28.8	7.22	7.85	7.75	221
21-2	28.1	-	-	-	-
22-1	27.5	7.50	7.95	7.65	184
22-2	27.6	7.95	7.90	7.45	205

Table A-2 Suspended Solids and Biomass

RUN No.	SS, MLSS				
	X_i	X_e	X_c	X_s	X_{ST}
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	g
1-1	456	32	4440	8010	8.23
1-2	422	30	5260	9540	0.18
1-3	370	30	5690	9450	1.19
2-1	250	30	5700	9500	12.02
2-2	290	25	6490	9120	9.70
3-1	292	6	5590	10140	10.84
3-2	360	54	5430	10040	11.44
4-1	236	7	5310	9200	4.38
4-2	119	5	5500	9100	5.10
5-1	170	13	5850	9260	6.39
5-2	194	9	5570	8740	6.78
6-1	117	9	5770	9710	2.67
6-2	216	29	5320	9850	4.35
6-3	220	45	6400	10760	3.51
6-4	173	30	6540	11380	6.63
7-1	108	35	6120	10580	4.15
8-1	133	64	5560	10300	4.50
9-1	175	8	3750	6050	5.31
9-2	172	16	3090	5690	4.56
9-3	196	34	3280	5570	2.74
9-4	128	37	2720	5180	2.95
9-5	261	160	2350	4410	3.66
9-6	308	62	2720	4380	3.90
9-7	-	-	2520	4350	2.67
9-8	430	52	3550	4330	2.19

Table A-2 Suspended Solids and Biomass (Cont'd)

RUN No.	SS, MLSS				
	X_i	X_e	X_c	X_s	X_{ST}
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	g
10-1	386	71	3950	5010	3.33
10-2	328	88	3730	5450	1.96
11-1	408	109	3220	5110	2.21
11-2	424	117	3250	5200	5.04
12-1	152	61	3070	5480	3.45
12-2	140	67	3250	5350	2.52
13-1	96	39	2480	4810	1.27
14-1	73	30	2550	5030	11.76
15-1	109	16	1650	2120	nil
15-2	68	13	1490	1900	nil
16-1	105	19	1260	2180	nil
16-2	154	49	1280	2350	nil
17-1	144	38	1600	2750	nil
17-2	177	46	1290	2370	nil
18-1	96	48	1440	2285	nil
18-2	110	46	1570	2400	nil
19-1	185	42	1530	2555	nil
20-1	318	32	640	888	nil
20-2	-	-	610	865	nil
20-3	-	-	710	900	nil
21-1	89	42	995	1115	nil
21-2	-	-	750	1115	nil
22-1	197	49	1355	1140	nil
22-2	-	-	585	837	nil

Table A-3 Volatile Suspended Solids and Biomass

RUN No.	VSS, MLVSS				
	X_{iv}	X_{ev}	X_{cv}	X_{sv}	X_{STv}
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	g
1-1	360	20	3180	5730	5.81
1-2	294	26	3660	6580	0.12
1-3	234	21	4160	6850	0.93
2-1	132	6	3604	6400	7.82
2-2	170	14	3990	6210	6.53
3-1	250	5	3600	6580	7.56
3-2	310	48	3550	6470	7.44
4-1	184	2	3800	6460	3.03
4-2	98	4	3830	6320	3.96
5-1	116	6	4260	6730	4.41
5-2	154	8	3900	6290	5.31
6-1	99	5	3830	6960	2.10
6-2	181	27	4260	7660	3.63
6-3	164	42	4910	8100	2.69
6-4	144	26	5020	8590	5.19
7-1	99	27	4940	8210	3.51
8-1	103	50	4390	8010	3.60
9-1	129	6	3040	4780	4.08
9-2	140	15	2440	4550	3.72
9-3	137	28	2540	4220	2.11
9-4	87	31	2050	3870	2.34
9-5	241	147	2000	3440	2.93
9-6	272	53	2110	3390	3.18
9-7	-	-	-	-	2.14
9-8	364	48	2910	3460	1.79

Table A-3 Volatile Suspended Solids and Biomass (Cont'd)

RUN No.	VSS, MLVSS				
	X_{iv}	X_{ev}	X_{cv}	X_{sv}	X_{STv}
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	g
10-1	324	66	3060	3910	2.97
10-2	296	80	2800	4120	1.75
11-1	350	102	2790	3980	1.75
11-2	386	110	2600	4200	4.20
12-1	128	51	2510	4350	2.76
12-2	132	60	2700	4340	2.40
13-1	77	31	1980	3860	1.00
14-1	57	26	2060	4070	9.63
15-1	83	12	1360	1730	nil
15-2	54	13	1190	1635	nil
16-1	80	18	1110	1810	nil
16-2	144	40	1160	2190	nil
17-1	112	31	1380	2450	nil
17-2	156	40	1140	2110	nil
18-1	78	43	1260	2045	nil
18-2	67	36	1320	2090	nil
19-1	176	39	1420	2290	nil
20-1	302	32	575	832	nil
20-2	-	-	525	810	nil
20-3	-	-	625	817	nil
21-1	76	37	910	1075	nil
21-2	-	-	700	1025	nil
22-1	172	49	1270	1080	nil
22-2	-	-	560	795	nil

Table A-4 Total Kjeldahl Nitrogen

RUN No.	TKN			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
1-1	125	20	nil	22
1-2	121	17	nil	24
1-3	115	nil	nil	nil
2-1	122	23	0	30
2-2	120	17	0	20
3-1	980	16.5	3.5	25
3-2	96	16	3	28
4-1	67	3.3	0	4.7
4-2	65	3	0	4
5-1	39.2	0	0	2
5-2	-	-	-	-
6-1	20.2	nil	nil	3.9
6-2	125	38	0	45
6-3	53	6.6	0	10
6-4	50	5	0	5
7-1	20	1.6	0	2.8
8-1	33	7	1	11
9-1	43	2	3	3
9-2	-	-	-	-
9-3	86	26	0	25
9-4	81	27	0	33
9-5	101	40	17.4	50
9-6	-	-	-	-
9-7	127	-	-	-
9-8	157	29	0	36

Table A-4 Total Kjeldahl Nitrogen (Cont'd)

RUN No.	TKN			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
10-1	176.4	70.0	12.3	82.8
10-2	172.5	59.4	5.6	73.4
11-1	180.3	59.4	1.6	73.4
11-2	-	-	-	-
12-1	52.1	12.9	3.9	17.9
12-2	-	-	-	-
13-1	48.7	18.5	6.2	21.8
14-1	26.6	12.9	3.9	12.9
15-1	31.4	5.6	0	16.8
15-2	30.8	6.2	3.9	7.3
16-1	100.8	28.6	5.0	28.6
16-2	-	-	-	-
17-1	-	-	-	-
17-2	101.6	40.6	11.2	48.7
18-1	92.9	36.9	5.6	38.6
18-2	-	-	-	-
19-1	105.8	40.3	5.0	45.4
20-1	97.4	40.3	16.8	44.8
20-2	-	-	-	-
20-3	-	-	-	-
21-1	85.1	29.1	9.5	30.2
21-2	-	-	-	-
22-1	95.5	34.7	8.1	40.8
22-2	-	-	-	-

Table A-5 Ammonia Nitrogen

RUN No.	NH_3- N			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
1-1	-	-	-	-
1-2	-	-	-	-
1-3	-	-	-	-
2-1	-	-	-	-
2-2	-	-	-	-
3-1	-	-	-	-
3-2	-	-	-	-
4-1	34	1	0	0
4-2	35	0	0	0
5-1	20	0	0	0
5-2	-	-	-	-
6-1	6.7	nil	0	0
6-2	-	-	-	-
6-3	27.6	1.6	0	1.2
6-4	-	-	-	-
7-1	4	0	0	0
8-1	20	4	0	4
9-1	20	1.5	0	1
9-2	-	-	-	-
9-3	57	16	0	18
9-4	51.5	13.5	0	16
9-5	70	31.4	6.7	30
9-6	-	-	-	-
9-7	-	-	-	-
9-8	108	25	0	29

Table A-5 Ammonia Nitrogen (Cont'd)

RUN No.	NH_3- N			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
10-1	121.5	58.8	10.8	59.9
10-2	123.2	46.5	0	43.7
11-1	132	51.5	1.1	53.2
11-2	-	-	-	-
12-1	28.7	10.4	0	7.1
12-2	-	-	-	-
13-1	20.7	11.8	3.9	10.6
14-1	15.7	7.8	0	6.2
15-1	12.2	0	0	0
15-2	-	-	-	-
16-1	49.3	20.7	0	16.8
16-2	-	-	-	-
17-1	-	-	-	-
17-2	26.3	19.9	8.9	17.6
18-1	23.5	18.2	0	16.8
18-2	-	-	-	-
19-1	11.2	21.3	0	18.5
20-1	44.8	12.8	0	14.5
20-2	-	-	-	-
21-1	-	-	-	-
21-2	23.5	7.3	0	6.7
22-1	-	-	-	-
22-2	14.0	13.4	0	11.5
22-2	-	-	-	-

Table A-6 Nitrite Nitrogen

RUN No.	NO_2			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
1-1	-	-	-	-
1-2	-	-	-	-
1-3	-	-	-	-
2-1	-	-	-	-
2-2	-	-	-	-
3-1	-	-	-	-
3-2	-	-	-	-
4-1	0	0.40	0.13	0.03
4-2	0	0.32	0.24	nil
5-1	0	0.09	0.05	0.08
5-2	0	0.13	0.02	0.08
6-1	0	nil	nil	nil
6-2	0	0.02	0.01	0.02
6-3	0	0	0	0
6-4	0	0	0	0
7-1	0	0	0	0
8-1	0	nil	nil	nil
9-1	0	nil	nil	nil
9-2	0	0.25	0.24	0.06
9-3	0	0.05	0.07	0.04
9-4	0	0.09	0.06	0.19
9-5	0	0.10	0.01	0.12
9-6	-	-	-	-
9-7	0	0.05	0	0.05
9-8	0	0.95	0.125	0.52

Table A-6 Nitrite Nitrogen (Cont'd)

RUN No.	NO_2			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
10-1	0	0.24	0.04	0.17
10-2	0	0.23	0.06	0.23
11-1	0	0.27	0.04	0.19
11-2	-	-	-	-
12-1	0	0.03	0	0.02
12-2	0	0.05	0.03	0.02
13-1	0	0.09	0.01	0.02
14-1	0	0	0	0
15-1	0	0.04	0.27	0.04
15-2	0	0.23	0.81	0.18
16-1	0	0.41	0.20	0.58
16-2	0	0.50	0.20	0.57
17-1	0	0.14	0.03	0.22
17-2	0	0.25	0.06	0.19
18-1	0	0.37	0	0.38
18-2	0	0.21	0	0.40
19-1	0	0.52	0	0.52
20-1	0	0.63	0.91	0.62
20-2	0	1.40	3.30	1.40
20-2	-	-	-	-
21-1	0	0.18	0.56	0.46
21-2	-	-	-	-
22-1	0	0.43	1.68	1.28
22-2	-	-	-	-

Table A-7 Nitrate Nitrogen

RUN No.	NO_3			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
1-1	-	-	-	-
1-2	-	-	-	-
1-3	-	-	-	-
2-1	-	-	-	-
2-2	-	-	-	-
3-1	-	-	-	-
3-2	-	-	-	-
4-1	0	40	48	45
4-2	0	57	47	52
5-1	0	12	25	27
5-2	-	-	-	-
6-1	0	nil	6.6	5.0
6-2	-	-	-	-
6-3	0	0	0	0
6-4	0	0	0	nil
7-1	0	0	0	0
8-1	0	0	0	0
9-1	-	-	-	-
9-2	-	-	-	-
9-3	0	nil	nil	nil
9-4	0	24	50	18
9-5	0	52	88	64
9-6	-	-	-	-
9-7	-	-	-	-
9-8	0	108.50	184.00	107.00

Table A-7 Nitrate Nitrogen (Cont'd)

RUN No.	NO_3			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
10-1	0	90.50	148.00	81.30
10-2	0	90.50	140.62	90.50
11-1	0	92.51	148.21	100.37
11-2	-	-	-	-
12-1	0	1.33	12.42	1.50
12-2	0	0.4	5.5	1.4
13-1	0	0.75	10.50	0.35
14-1	0	0	0	0
15-1	0	0.44	2.50	0.41
15-2	-	-	-	-
16-1	0	19.37	57.00	22.66
16-2	0	35.00	77.50	34.16
17-1	0	17.80	54.00	22.50
17-2	0	17.50	61.00	24.33
18-1	0	4.58	37.50	5.16
18-2	0	4.75	29.00	5.25
19-1	0	2.24	44.00	8.71
20-1	0	22.00	44.25	27.00
20-2	0	6.68	19.25	6.25
20-3	-	-	-	-
21-1	0	5.16	29.53	10.34
21-2	-	-	-	-
22-1	0	3.50	29.25	12.25
22-2	-	-	-	-

Table A-8 Phosphate Phosphorus

RUN No.	PO_4			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
1-1	45	20	7	20
1-2	45	13	12	19
1-3	41	18	21	21
2-1	45	29	29	22
2-2	48	29	30	26
3-1	32	24	26	16
3-2	35	18	30	18
4-1	50	21	23	25
4-2	54	49	39	45
5-1	30	7	15	10
5-2	-	-	-	-
6-1	40	13.6	5.7	12.2
6-2	45	14	15	40
6-3	36	12	21	16
6-4	-	-	-	-
7-1	36	21	16	19
8-1	42	10	11	10
9-1	10	6	9	5
9-2	-	-	-	-
9-3	28	13	14	13
9-4	-	-	-	-
9-5	35	14	19	16
9-6	-	-	-	-
9-7	45	19	23	22
9-8	42	22	21	23

Table A-8 Phosphate Phosphorus (Cont'd)

RUN No.	PO_4			
	INF_T	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
10-1	-	-	-	-
10-2	33	22	17	20
11-1	64	28	56	26
11-2	42	29	36	39
12-1	-	-	-	-
12-2	-	-	-	-
13-1	28	17	15	20
14-1	27	17	19	23
15-1	32	16	16	18
15-2	-	-	-	-
16-1	50	14	14	19
17-1	-	-	-	-
17-2	-	-	-	-
18-1	25	9	8	7
18-2	18	5	6	6
19-1	-	-	-	-
20-1	35	20	11	15
20-2	45	14	12	12
20-3	-	-	-	-
21-1	-	-	-	-
21-2	28	11	9	12
22-1	-	-	-	-
22-2	17	6	5	5
22-2	-	-	-	-

Table A-9 Biochemical Oxygen Demand

RUN No.	BOD_5				
	INF_T	INF_S	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
1-1	-	-	-	-	-
1-2	-	-	-	-	-
1-3	-	-	-	-	-
2-1	460	414	9	8	24
2-2	475	300	4	4	33
3-1	400	242	10	9	17
3-2	-	-	-	-	-
4-1	500	444	3	2	6
4-2	303	243	2	2	4
5-1	604	530	3	4	10
5-2	552	400	5	3	12
6-1	-	-	-	-	-
6-2	-	-	-	-	-
6-3	1000	716	28	5	40
6-4	-	-	-	-	-
7-1	810	675	41	13	56
8-1	625	550	40	13	68
9-1	733	457	3	4	4
9-2	-	-	-	-	-
9-3	-	-	-	-	-
9-4	700	571	35	12	58
9-5	400	233	18	11	180
9-6	-	-	-	-	-
9-7	-	-	-	-	-
9-8	350	142	30	21	40

Table A-9 Biochemical Oxygen Demand (Cont'd)

RUN No.	BOD_5				
	INF_T	INF_S	C	S	EFF_T
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
10-1	-	-	-	-	-
10-2	283	108	30	11	80
11-1	-	-	-	-	-
11-2	260	66	37	6	60
12-1	-	-	-	-	-
12-2	-	-	-	-	-
13-1	-	-	-	-	-
14-1	908	866	373	10	415
15-1	620	517	18	6	19
15-2	-	-	-	-	-
16-1	-	-	-	-	-
16-2	-	-	-	-	-
17-1	-	-	-	-	-
17-2	642	428	24	5	40
18-1	728	625	26	7	57
18-2	-	-	-	-	-
19-1	-	-	-	-	-
20-1	-	-	-	-	-
20-2	-	-	-	-	-
20-3	-	-	-	-	-
21-1	-	-	-	-	-
21-2	-	-	-	-	-
22-1	600	415	60	13	80
22-2	-	-	-	-	-

APPENDIX B

EFFLUENT STANDARD REGULATED BY MINISTRY OF INDUSTRY

Table B1 - WORKING STANDARDS FOR EFFLUENT DISCHARGING TO INLAND STREAMS REGULATE BY MINISTRY OF INDUSTRY

BOD (5 days 20°C)	max	20	ppm
Suspended solids	max	30	ppm
Dissolved solids	max	2,000	ppm
pH value	between 5 and 9		
Permanganate value	max	60	ppm
Sulphide (as H_2S)	max	1	ppm
Cyanide (as HCN)	max	0.2	ppm
Oils and grease	none		
Tar	none		
Formaldehyde	max	1	ppm
Phenols and cresols	max	1	ppm
Free chlorine	max	1	ppm
Zinc, Chromium, Copper, Arsenic, Mercury, Silver, Cadmium, Selenium, Barium, Lead, Selenium, Nickel	Individually or in total, max	1	ppm
Insecticides	none		
Radioactive materials	none		
Temperature	max	40°C	
No disagreeable taste and odour			

Standard for Wastewater Effluents

Discharging to Inland Streams of High Dilution Ratio

Volumes of Dilution	Max. Permitted Suspended Solids
8 - 150	30
150 - 300	60
300 - 500	150

VITA

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