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APPENDICES

APPENDIX A

ORP, pH and Temperature during prepare the sludge seeding

Table A-1 ORP, pH and Temperature during prepare the sludge seeding

		ORP	pH	Temp
11/1/2005	1	-103.6	6.75	28.2
12/1/2005	2	-121.3	6.73	28.5
13/1/2005	3	-127	6.77	29
14/1/2005	4	-141	6.72	28.8
15/1/2005	5	-138	6.76	29.1
16/1/2005	6	-130	6.82	28.6
17/1/2005	7	-123.2	6.91	29.3
18/1/2005	8	-120	6.87	28.7
19/1/2005	9	-146.5	6.65	28.7
20/1/2005	10	-150.2	6.4	28.9
21/1/2005	11	-152	6.53	29
22/1/2005	12	-162	6.62	28.6
23/1/2005	13	-154	6.72	28.7
24/1/2005	14	-155.6	6.83	29.3
25/1/2005	15	-158.9	6.87	29.6
26/1/2005	16	-138.6	7	28.7
27/1/2005	17	-172.5	6.87	28
28/1/2005	18	-152.6	6.86	28.9
29/1/2005	19	-157	6.88	29.2
30/1/2005	20	-160	6.88	29.5
31/1/2005	21	-162.4	6.86	30
1/2/2005	22	-165.1	6.87	30
2/2/2005	23	-170	6.88	29.8
3/2/2005	24	-162	6.97	29
4/2/2005	25	-152.7	6.94	29.6
5/2/2005	26	-160.2	6.98	30.1
6/2/2005	27	-162.5	6.98	29.8
7/2/2005	28	-170.2	6.97	29.6
8/2/2005	29	-175.2	6.98	29.5
9/2/2005	30	-173.8	6.97	29.7
10/2/2005	31	-177.6	6.96	29.6
11/2/2005	32	-179.2	6.97	29.3
12/2/2005	33	-170.1	6.95	29.8
13/2/2005	34	-180.2	6.93	29.9
14/2/2005	35	-172	6.97	30.2
15/2/2005	36	-180.4	6.98	30.1
16/2/2005	37	-182.7	6.98	29.7
17/2/2005	38	-188.5	6.95	30.1
18/2/2005	39	-190.2	6.97	30.8

APPENDIX B

Alkalinity, Volatile Fatty Acid, VFA/Alk Ratio and Total Kjedahl Nitrogen during experiment

Table B-1 Alkalinity, Volatile Fatty Acid, VFA/Alk ratio and Total Kjedahl Nitrogen of the reactor mixture in the reactor during the experiment

	day	Alk (mg./l.)	VFA(mg./l.)	VFA/Alk	TKN(mg./l.)
20/2/2005	1	75	30	0.4	106.4
22/2/2005	3	95	60	0.63158	116.7
24/2/2005	5	120	40	0.33333	128.8
26/2/2005	7	115	45	0.3913	125
28/2/2005	9	110	40	0.36364	123.2
2/3/2005	11	110	45	0.40909	112.3
4/3/2005	13	105	40	0.38095	117.5
6/3/2005	15	95	45	0.47368	121.2
8/3/2005	17	100	40	0.4	126.1
10/3/2005	19	105	35	0.33333	130.6
12/3/2005	21	115	35	0.30435	133.5
14/3/2005	23	95	35	0.36842	137.2
16/3/2005	25	90	35	0.38889	135.2
18/3/2005	27	85	35	0.41176	134.3
20/3/2005	29	90	35	0.38889	131.6
22/3/2005	31	80	40	0.5	115.6
24/3/2005	33	60	45	0.75	89.6
26/3/2005	35	45	50	1.11111	103.6

APPENDIX C

Total Chemical Oxygen Demand and Dissolved Chemical Oxygen Demand during experiment

Table C -1 Total Chemical Oxygen Demand and Dissolved Chemical Oxygen Demand of the reactor mixture in the reactor during the experiment

COD

	day	Total COD (mg/l)	Dissolved COD (mg/l)
20/2/2005	1		
21/2/2005	2	118,400	473.6
22/2/2005	3	61,300	467.9
23/2/2005	4	56,100	442
24/2/2005	5	15,900	440
25/2/2005	6	27,000	337
26/2/2005	7	18,800	342
27/2/2005	8	19,800	332
28/2/2005	9	21,700	302
1/3/2005	10	25,300	295
2/3/2005	11	23,100	286
3/3/2005	12	26,800	272
4/3/2005	13	29,500	263
5/3/2005	14	44,500	232
6/3/2005	15	23,100	295
7/3/2005	16	20,000	263
8/3/2005	17	28,000	320
9/3/2005	18	26,400	305
10/3/2005	19	25,000	260
11/3/2005	20	23,000	245
12/3/2005	21	24,500	180
13/3/2005	22	24,200	125
14/3/2005	23	68,200	362
15/3/2005	24	49,400	169
16/3/2005	25	32,300	162
17/3/2005	26	28,600	142
18/3/2005	27	24,200	149
19/3/2005	28	23,100	153
20/3/2005	29	20,500	147
21/3/2005	30	33,200	306
22/3/2005	31	19,800	204
23/3/2005	32	21,800	195
24/3/2005	33	20,100	183
25/3/2005	34	21,500	178
26/3/2005	35	22,100	180

APPENDIX D

Gas Production during in the reactors during the experiment

Table D-1 Gas Production in the reactors during the experiment

Gas Product (ml.)

	day	First Reactor	Second reactor
20/2/2005	1	0.0	0.0
21/2/2005	2	1.0	1.1
22/2/2005	3	1.2	1.4
23/2/2005	4	1.5	1.1
24/2/2005	5	1.1	1.2
25/2/2005	6	1.0	1.0
26/2/2005	7	0.8	1.2
27/2/2005	8	0.9	1.2
28/2/2005	9	1.2	1.1
1/3/2005	10	1.3	1.4
2/3/2005	11	1.1	1.0
3/3/2005	12	1.0	1.0
4/3/2005	13	1.2	1.1
5/3/2005	14	1.4	1.0
6/3/2005	15	0.9	0.9
7/3/2005	16	1.0	0.9
8/3/2005	17	1.2	1.0
9/3/2005	18	1.3	1.5
10/3/2005	19	1.4	1.2
11/3/2005	20	1.1	1.0
12/3/2005	21	0.9	0.8
13/3/2005	22	1.3	1.1
14/3/2005	23	1.1	1.1
15/3/2005	24	1.2	1.0
16/3/2005	25	0.9	1.2
17/3/2005	26	1.7	1.1
18/3/2005	27	1.5	1.2
19/3/2005	28	1.5	1.2
20/3/2005	29	1.8	1.9
21/3/2005	30	2.1	1.8
22/3/2005	31	2.0	
23/3/2005	32	2.2	
24/3/2005	33	1.8	
25/3/2005	34	1.1	

APPENDIX E

Mixed Liquor Suspended Solids during the experiment

Table E-1 Mixed Liquor Suspended Solids during the experiment

MLSS (g/l)

	day	Reactor1
20/2/2005	1	28,750
21/2/2005	2	25,510
22/2/2005	3	23,950
23/2/2005	4	20,650
24/2/2005	5	22,030
25/2/2005	6	21,830
26/2/2005	7	20,994
27/2/2005	8	24,360
28/2/2005	9	22,200
1/3/2005	10	22,510
2/3/2005	11	25,080
3/3/2005	12	20,340
4/3/2005	13	22,860
5/3/2005	14	21,860
6/3/2005	15	21,960
7/3/2005	16	19,260
8/3/2005	17	22,750
9/3/2005	18	22,160
10/3/2005	19	24,950
11/3/2005	20	23,540
12/3/2005	21	23,290
13/3/2005	22	21,810
14/3/2005	23	19,450
15/3/2005	24	19,530
16/3/2005	25	21,220
17/3/2005	26	21,100
18/3/2005	27	17,250
19/3/2005	28	19,370
20/3/2005	29	17,770
21/3/2005	30	17,260
22/3/2005	31	19,520
23/3/2005	32	20,130
24/3/2005	33	18,950
25/3/2005	34	20,580

APPENDIX F

ORP during the start up reactor and operation reactor

Table F-1 ORP during the start up reactor and operation reactor

ORP(mV.)

	day	First reactor	Second reactor
20/2/2005	1	-49.70	-49.70
21/2/2005	2	-138.30	-137.20
22/2/2005	3	-161.00	-158.50
23/2/2005	4	-181.60	-176.20
24/2/2005	5	-191.00	-192.30
25/2/2005	6	-127.60	-135.20
26/2/2005	7	-155.20	-152.40
27/2/2005	8	-146.20	-150.20
28/2/2005	9	-147.20	-148.50
1/3/2005	10	-125.30	-128.20
2/3/2005	11	-127.20	-130.80
3/3/2005	12	-128.00	-133.50
4/3/2005	13	-131.00	-142.60
5/3/2005	14	-152.30	-156.70
6/3/2005	15	-150.20	-153.20
7/3/2005	16	-135.20	-138.20
8/3/2005	17	-139.80	-146.20
9/3/2005	18	-140.00	-155.20
10/3/2005	19	-145.20	-146.10
11/3/2005	20	-151.50	-154.20
12/3/2005	21	-147.20	-146.20
13/3/2005	22	-149.30	-158.20
14/3/2005	23	-152.70	-161.00
15/3/2005	24	-143.90	-152.20
16/3/2005	25	-132.90	-134.40
17/3/2005	26	-135.60	-137.50
18/3/2005	27	-137.60	-139.20
19/3/2005	28	-100.00	-101.20
20/3/2005	29	-78.50	-86.20
21/3/2005	30	-126.00	-132.20
22/3/2005	31	-157.20	-155.20
23/3/2005	32	-129.20	
24/3/2005	33	-122.50	
25/3/2005	34	-56.6	
26/3/2005	35	52.2	

APPENDIX G

pH during the start up reactor and operation reactor

Table G-1 pH during the start up reactor and operation reactors

pH

	day	First reactor	Second reactor
20/2/2005	1	7.25	7.25
21/2/2005	2	7.25	7.25
22/2/2005	3	7.17	7.18
23/2/2005	4	7.13	7.14
24/2/2005	5	7.28	7.27
25/2/2005	6	7.27	7.25
26/2/2005	7	7.26	7.26
27/2/2005	8	7.27	7.28
28/2/2005	9	7.25	7.27
1/3/2005	10	7.00	7.05
2/3/2005	11	7.10	7.08
3/3/2005	12	7.10	7.09
4/3/2005	13	7.22	7.23
5/3/2005	14	7.09	7.10
6/3/2005	15	6.95	6.95
7/3/2005	16	7.01	7.05
8/3/2005	17	7.05	7.10
9/3/2005	18	7.16	7.19
10/3/2005	19	7.19	7.20
11/3/2005	20	7.20	7.22
12/3/2005	21	7.21	7.22
13/3/2005	22	7.28	7.29
14/3/2005	23	7.20	7.20
15/3/2005	24	7.20	7.21
16/3/2005	25	7.17	7.19
17/3/2005	26	7.16	7.20
18/3/2005	27	7.13	7.14
19/3/2005	28	7.16	7.17
20/3/2005	29	7.15	7.18
21/3/2005	30	7.15	7.14
22/3/2005	31	7.09	
23/3/2005	32	6.99	
24/3/2005	33	6.97	
25/3/2005	34	6.89	
26/3/2005	35	6.77	

APPENDIX H

Relationship between ph and phase of sulfide

Table G-1 Relationship between ph and phase of sulfide

Relationship between ph and phase of sulfide

	H	H_2S			HS^-			S^{2-}			Total S
pH	M	%	mg.	M	%	mg.	M	%	mg.	M	mg.
4.00	1.00E-04	99.90	999.03	29.38	0.10	0.97	2.94E-02	0.00	0.00	3.70E-12	1000
4.25	5.62E-05	99.83	998.28	29.36	0.17	1.72	5.22E-02	0.00	0.00	1.17E-11	1000
4.50	3.16E-05	99.69	996.94	29.32	0.31	3.06	9.27E-02	0.00	0.00	3.69E-11	1000
4.75	1.78E-05	99.46	994.57	29.25	0.54	5.43	1.64E-01	0.00	0.00	1.17E-10	1000
5.00	1.00E-05	99.04	990.39	29.13	0.96	9.61	2.91E-01	0.00	0.00	3.67E-10	1000
5.25	5.62E-06	98.30	983.03	28.91	1.70	16.97	5.14E-01	0.00	0.00	1.15E-09	1000
5.50	3.16E-06	97.02	970.22	28.54	2.98	29.78	9.02E-01	0.00	0.00	3.60E-09	1000
5.75	1.78E-06	94.82	948.24	27.89	5.18	51.76	1.57E+00	0.00	0.00	1.11E-08	1000
6.00	1.00E-06	91.15	911.53	26.81	8.85	88.47	2.68E+00	0.00	0.00	3.38E-08	1000
6.25	5.62E-07	85.28	852.81	25.08	14.72	147.19	4.46E+00	0.00	0.00	9.99E-08	1000
6.50	3.16E-07	76.52	765.15	22.50	23.48	234.85	7.12E+00	0.00	0.00	2.84E-07	1000
6.75	1.78E-07	64.69	646.91	19.03	35.31	353.09	1.07E+01	0.00	0.00	7.58E-07	1000
7.00	1.00E-07	50.75	507.46	14.93	49.25	492.54	1.49E+01	0.00	0.00	1.88E-06	1000
7.25	5.62E-08	36.68	366.84	10.79	63.32	633.16	1.92E+01	0.00	0.00	4.30E-06	1000
7.50	3.16E-08	24.57	245.74	7.23	75.43	754.26	2.29E+01	0.00	0.00	9.11E-06	1000
7.75	1.78E-08	15.48	154.85	4.55	84.52	845.15	2.56E+01	0.00	0.00	1.81E-05	1000
8.00	1.00E-08	9.34	93.41	2.75	90.66	906.59	2.75E+01	0.00	0.00	3.46E-05	1000
8.25	5.62E-09	5.48	54.77	1.61	94.52	945.23	2.86E+01	0.00	0.00	6.42E-05	1000
8.50	3.16E-09	3.16	31.55	0.93	96.84	968.44	2.93E+01	0.00	0.00	1.17E-04	1000
8.75	1.78E-09	1.80	17.99	0.53	98.20	982.00	2.98E+01	0.00	0.01	2.11E-04	1000
9.00	1.00E-09	1.02	10.20	0.30	98.98	989.79	3.00E+01	0.00	0.01	3.78E-04	1000
9.25	5.62E-10	0.58	5.76	0.17	99.42	994.22	3.01E+01	0.00	0.02	6.75E-04	1000
9.50	3.16E-10	0.32	3.25	0.10	99.67	996.71	3.02E+01	0.00	0.04	1.20E-03	1000
9.75	1.78E-10	0.18	1.83	0.05	99.81	998.10	3.02E+01	0.01	0.07	2.14E-03	1000
10.00	1.00E-10	0.10	1.03	0.03	99.88	998.85	3.03E+01	0.01	0.12	3.81E-03	1000
10.25	5.62E-11	0.06	0.58	0.02	99.92	999.20	3.03E+01	0.02	0.22	6.78E-03	1000
10.50	3.16E-11	0.03	0.33	0.01	99.93	999.29	3.03E+01	0.04	0.39	1.21E-02	1000
10.75	1.78E-11	0.02	0.18	0.01	99.91	999.13	3.03E+01	0.07	0.69	2.15E-02	1000
11.00	1.00E-11	0.01	0.10	0.00	99.87	998.68	3.03E+01	0.12	1.22	3.81E-02	1000
11.25	5.62E-12	0.01	0.06	0.00	99.78	997.78	3.02E+01	0.22	2.17	6.77E-02	1000
11.50	3.16E-12	0.00	0.03	0.00	99.61	996.12	3.02E+01	0.38	3.85	1.20E-01	1000
11.75	1.78E-12	0.00	0.02	0.00	99.32	993.16	3.01E+01	0.68	6.82	2.13E-01	1000
12.00	1.00E-12	0.00	0.01	0.00	98.79	987.93	2.99E+01	1.21	12.07	3.77E-01	1000
12.25	5.62E-13	0.00	0.01	0.00	97.87	978.75	2.97E+01	2.13	21.27	6.65E-01	1000
12.50	3.16E-13	0.00	0.00	0.00	96.28	962.83	2.92E+01	3.72	37.20	1.16E+00	1000
12.75	1.78E-13	0.00	0.00	0.00	93.58	935.76	2.84E+01	6.43	64.29	2.01E+00	1000
13.00	1.00E-13	0.00	0.00	0.00	89.12	891.20	2.70E+01	10.89	108.89	3.40E+00	1000
13.25	5.62E-14	0.00	0.00	0.00	82.16	821.63	2.49E+01	17.85	178.52	5.58E+00	1000
13.50	3.16E-14	0.00	0.00	0.00	72.15	721.48	2.19E+01	27.88	278.76	8.71E+00	1000
13.75	1.78E-14	0.00	0.00	0.00	59.29	592.95	1.80E+01	40.74	407.40	1.27E+01	1000
14.00	1.00E-14	0.00	0.00	0.00	45.03	450.29	1.36E+01	55.02	550.18	1.72E+01	1000

APPENDIX I

Sulfate during the start up reactor and operation reactors

Table I-1 Standard sulfate for calibration curve during the 1st to the 15th day

Calibration curve

Standard	
Sulfate(mg/l)	Abs
0	0
1	0.078
2	0.198
3	0.344
4	0.465
5	0.576
6	0.726
7	0.761

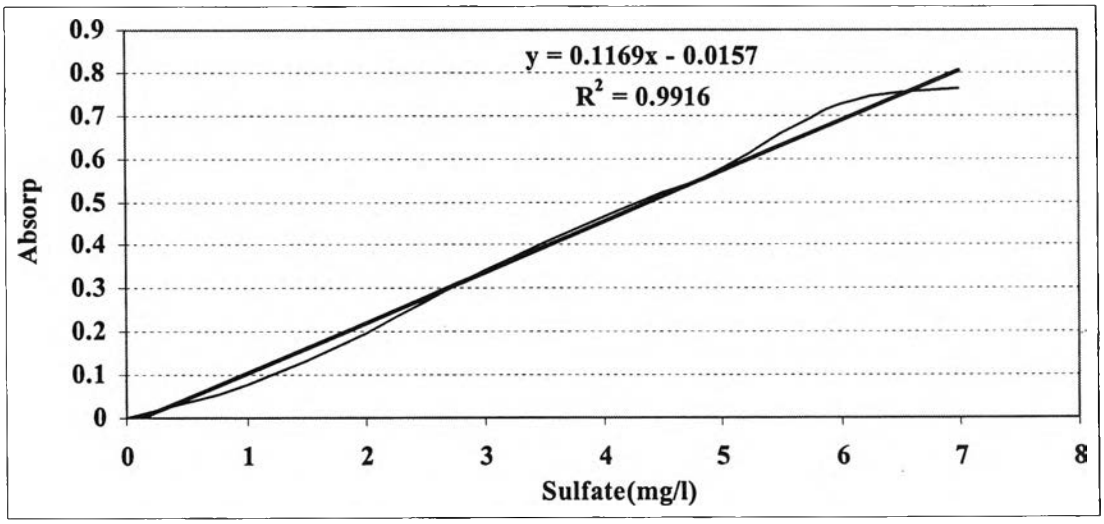

Figure I-1 Calibration curve for the 1st to the 15th day

Table I-2 Absorption and sulfate during the 1st to the 15th day

		Absorption		Sulfate
20/2/2005	1	0.113	1.1	11
21/2/2005	2	0.101	1	10
22/2/2005	3	0.090	0.9	9
23/2/2005	4	0.054	0.6	6
24/2/2005	5	0.031	0.4	4
25/2/2005	6	0.019	0.3	3
26/2/2005	7	0.019	0.3	3
27/2/2005	8	0.019	0.3	3
28/2/2005	9	0.019	0.3	3
1/3/2005	10	0.043	0.5	5
2/3/2005	11	0.019	0.3	3
3/3/2005	12	0.019	0.3	3
4/3/2005	13	0.265	2.4	24
5/3/2005	14	0.218	2	20
6/3/2005	15	0.160	1.5	15

Table I-3 Standard sulfate for calibration curve during the 1st to the 15th day

Calibration curve

Standard	
Sulfate(mg/l.)	Abs
0	0
1	0.118
2	0.18
3	0.332
4	0.508
5	0.575
6	0.519
7	0.82
8	0.768

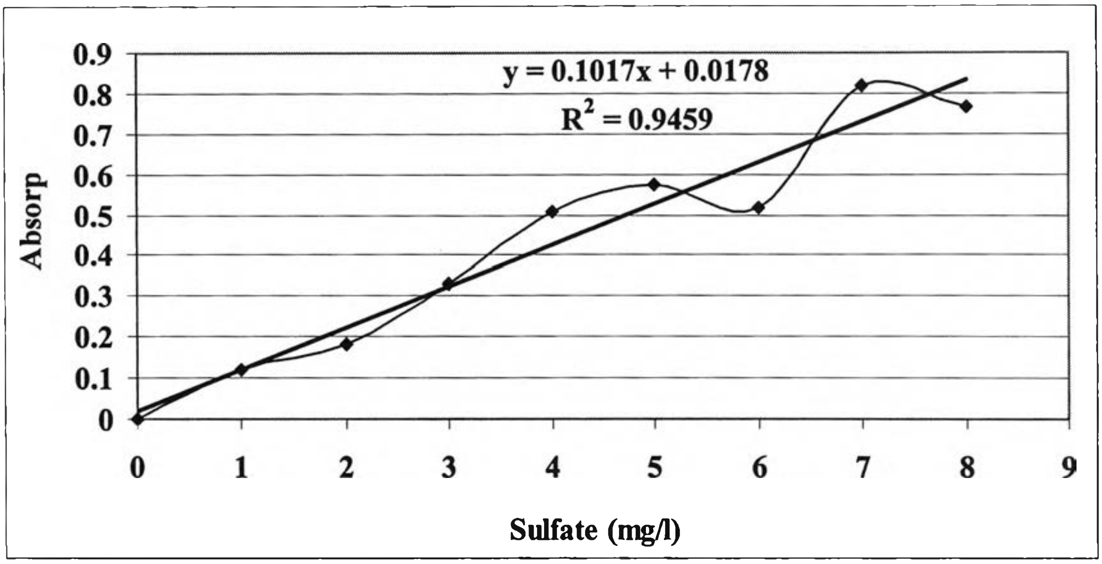

Figure I-2 Calibration curve for the 16th to the 35th day

Table I-4 Absorption and sulfate during the 16th to the 35th day

		Absorption		Sulfate
7/3/2005	16	0.160	1.4	14
8/3/2005	17	0.150	1.3	13
9/3/2005	18	0.140	1.2	12
10/3/2005	19	0.130	1.1	11
11/3/2005	20	0.120	1	10
12/3/2005	21	0.120	1	10
13/3/2005	22	0.099	0.8	8
14/3/2005	23	0.109	0.9	9
15/3/2005	24	0.109	0.9	9
16/3/2005	25	0.109	0.9	9
17/3/2005	26	0.109	0.9	9
18/3/2005	27	0.089	0.7	7
19/3/2005	28	0.109	0.9	9
20/3/2005	29	0.109	0.9	9
21/3/2005	30	0.109	0.9	9
22/3/2005	31	0.109	0.9	9
23/3/2005	32	0.191	1.7	17
24/3/2005	33	0.191	1.7	17
25/3/2005	34	0.313	2.9	29
26/3/2005	35	0.740	7.1	71

Table I-5 Sulfate during the start up reactor and operation reactors.

Sulfate (SO_4^{2-})(mg/L)

	day	Reactor1
20/2/2005	1	11
21/2/2005	2	10
22/2/2005	3	9
23/2/2005	4	6
24/2/2005	5	4
25/2/2005	6	3
26/2/2005	7	3
27/2/2005	8	3
28/2/2005	9	3
1/3/2005	10	5
2/3/2005	11	3
3/3/2005	12	3
4/3/2005	13	24
5/3/2005	14	20
6/3/2005	15	15
7/3/2005	16	14
8/3/2005	17	13
9/3/2005	18	12
10/3/2005	19	11
11/3/2005	20	10
12/3/2005	21	10
13/3/2005	22	8
14/3/2005	23	9
15/3/2005	24	9
16/3/2005	25	9
17/3/2005	26	9
18/3/2005	27	7
19/3/2005	28	9
20/3/2005	29	9
21/3/2005	30	9
22/3/2005	31	9
23/3/2005	32	17
24/3/2005	33	17
25/3/2005	34	29
26/3/2005	35	71

APPENDIX J

Sulfide during the start up reactor, operation reactors and every injection synthesized wastewater

Table J-1 Sulfide during the start up reactor, operation reactors and every injection synthesized wastewater.

Sulfide (mg/L,ppm)

	day	Reactor1
20/2/2005	1	1.2
21/2/2005	2	2
22/2/2005	3	4
23/2/2005	4	6
24/2/2005	5	8
25/2/2005	6	8
26/2/2005	7	8
27/2/2005	8	8
28/2/2005	9	8
1/3/2005	10	6
2/3/2005	11	8
3/3/2005	12	8
4/3/2005	13	36
5/3/2005	14	40
6/3/2005	15	46
7/3/2005	16	46
8/3/2005	17	48
9/3/2005	18	48
10/3/2005	19	50
11/3/2005	20	50
12/3/2005	21	50
13/3/2005	22	52
14/3/2005	23	52
15/3/2005	24	52
16/3/2005	25	52
17/3/2005	26	52
18/3/2005	27	54
19/3/2005	28	52
20/3/2005	29	52
21/3/2005	30	52
22/3/2005	31	52
23/3/2005	32	44
24/3/2005	33	44
25/3/2005	34	40
26/3/2005	35	0

The first of zinc injection (10ppm)

		Time	Reactor1
2-28-05	1	0 min.	8
	2	30 min.	2
	3	60 min.	2
	4	90 min.	2
	5	120 min.	4
	6	3hr.	4
	7	6hr.	6
	8	9hr.	6
	9	12hr.	8
	10	15 hr.	8

The second of zinc injection (20ppm)

		Time	Reactor1
14/3/2005	1	0 min.	52
	2	10 min.	42
	3	20 min.	42
	4	30 min.	42
	5	40 min.	42
	6	50 min.	44
	7	60 min.	44

The third of zinc injection (20ppm)

		Time	Reactor1
16/3/2005	1	0 min.	52
	2	10 min.	42
	3	20 min.	42
	4	30 min.	42
	5	40 min.	44
	6	50 min.	44
	7	60 min.	44

The forth of zinc injection (20ppm)

		Time	Reactor1
19/3/2005	1	0 min.	52
	2	10 min.	42
	3	20 min.	42
	4	30 min.	42
	5	40 min.	42
	6	50 min.	44
	7	60 min.	44

The fifth of zinc injection (20ppm)

		Time	Reactor1
20/3/2005	1	0 min.	52
	2	10 min.	42
	3	20 min.	42
	4	30 min.	42
	5	40 min.	42
	6	50 min.	44
	7	60 min.	44

The sixth of zinc injection (50ppm)

		Time	Reactor1
22/3/2005	1	0 min.	52
	2	10 min.	24
	3	20 min.	24
	4	30 min.	24
	5	40 min.	26
	6	50 min.	26
	7	60 min.	28

The seventh of zinc injection (50ppm)

		Time	Reactor1
23/3/2005	1	0 min.	44
	2	10 min.	20
	3	20 min.	20
	4	30 min.	20
	5	40 min.	22
	6	50 min.	24
	7	60 min.	24

The eighth of zinc injection (100ppm)

		Time	Reactor1
24/3/2005	1	0 min.	44
	2	10 min.	6
	3	20 min.	6
	4	30 min.	5
	5	40 min.	4
	6	50 min.	4
	7	60 min.	4

The ninth of zinc injection (100ppm)

		Time	Reactor1
25/3/2005	1	0 min.	40
	2	10 min.	0
	3	20 min.	0
	4	30 min.	0
	5	40 min.	0
	6	50 min.	0
	7	60 min.	0

APPENDIX K

Sulfur Mass Balance

Sulfur mass balance

Total Sulfur at the beginning (Start up) 1st day.

1. Residual sulfide in the sludge seeding	= 1.0 mg/l = 1.0 x 2	= 2.0 mg
2. Nutrient ($MgSO_4.7H_2O$)	= 1.0 mg/l = 1.0 x 2	= 2.0 mg
3. Adding $MgSO_4.7H_2O$	= 10.4 mg/l= 10.4 x 2	= 20.8 mg
Total sulfur at the beginning	= 2.0+2.0+20.8	= 24.8 mg

Mass balance for 1st injection synthesized wastewater

Before injection

1. Residual sulfide in the reactor	= 8.0 mg/l = 8.0 x 2	= 16.0 mg
2. Residual sulfate in the reactor	= 3.0 mg/l = 3.0 x 2	= 6.0 mg
3. Synthesized wastewater	= 5.0 mg/l = 5.0 x 2	= 10.0 mg
Total dissolved sulfur	= 16.0+6.0+10.0	= 32.0 mg

After 1st injection (1day)

1. Residual sulfide in the reactor	= 6.0 mg/l = 6.0 x 2	= 12.0 mg
2. Residual sulfate in the reactor	= 5.0 mg/l = 5.0 x 2	= 10.0 mg
3. Precipitate with Zn in synthesized wastewater	= 5.0 mg/l = 5.0 x 2	= 10.0 mg

* zinc 10 ppm in synthesis wastewater and all of them precipitate with sulfide in the reactor.

$$Zn^{2+} + S^{2-} \dashrightarrow ZnS$$

$$10\ mg/65 + 5mg/32 = 15mg/97$$

Then Zinc 10 mg/l precipitate with sulfide 5 mg/l

Total dissolved sulfur after 1st injection = 12.0+10.0 = 22.0 mg

Precipitated sulfur in this injection = 10 mg

Total accumulative precipitated sulfur = 10 mg

Total Sulfur in reactor = 22.0+10.0 = 32.0 mg

Mass balance for 3/3/2005 (added SO_4^{2} 50 mg/l)

1. Residual sulfide in the reactor = 8.0 mg/l = 8.0 x 2 = 16.0 mg
2. Residual sulfate in the reactor = 3.0 mg/l = 3.0 x 2 = 6.0 mg
3. Adding $MgSO_4.7H_2O$ = 50.0 mg/l = 50.0 x 2 = 100 mg
4. Precipitated sulfur (ZnS) = 5.0 mg/l = 5.0 x 2 = 10.0 mg

Total dissolved sulfur = 16.0+6+100 = 122.0 mg

Total accumulative precipitated sulfur = 10.0 mg

Total Sulfur in reactor = 122.0+10.0 = 132.0 mg

Mass balance for 2nd injection synthesized wastewater

Before injection

1. Residual sulfide in the reactor = 52.0 mg/l = 52.0 x 2 = 104 mg
2. Residual sulfate in the reactor = 9.0 mg/l = 9.0 x 2 = 18.0 mg
3. Synthesized wastewater = 10.0 mg/l = 10.0 x 2 = 20.0 mg

Total dissolved sulfur = 104.0 + 18.0 + 20.0 =142.0 mg

Total accumulative precipitated sulfur = 10.0 mg

After 2nd injection (1day)

1. Residual sulfide in the reactor = 52.0 mg/l = 52.0 x 2 = 104 mg
2. Residual sulfate in the reactor = 9.0 mg/l = 9.0 x 2 = 18.0 mg
3. Precipitate with Zn in synthesized wastewater= 10.0 mg/l = 10.0 x 2 = 20 mg

* zinc 20 ppm in synthesis wastewater and all of them precipitate with sulfide in the reactor.

$$Zn^{2+} + S^{2-} \dashrightarrow ZnS$$

20 mg/65 + 10mg/32 = 30mg/97

Then zinc 20 mg/l precipitate with sulfide 10 mg/l

Total dissolved sulfur after 2nd injection = 104.0 + 18.0 = 122.0 mg

Precipitated sulfur in this injection = 20.0 mg

Total accumulative precipitated sulfur = 10.0 + 20.0 = 30.0 mg

Total sulfur in reactor = 142.0 + 10.0 = 152.0 mg

Mass balance for 3rd injection synthesized wastewater

Before injection

1. Residual sulfide in the reactor = 52.0 mg/l = 52.0 x 2 = 104 mg
2. Residual sulfate in the reactor = 9.0 mg/l = 9.0 x 2 = 18.0 mg
3. Synthesized wastewater = 10.0 mg/l = 10.0 x 2 = 20.0 mg

Total dissolved sulfur when injection = 104.0 + 18.0 + 20.0 =142.0 mg

Total accumulative precipitated sulfur = 30.0 mg

After 3rd injection (1day)

1. Residual sulfide in the reactor = 52.0 mg/l = 52.0 x 2 = 140 mg
2. Residual sulfate in the reactor = 9.0 mg/l = 9.0 x 2 = 18.0 mg
3. Precipitate with Zn in synthesized wastewater= 10.0 mg/l = 10.0 x 2 = 20.0 mg

*zinc 20 ppm in synthesis wastewater and all of them precipitate with sulfide in the reactor.

Then Zinc 20 mg/l precipitate with sulfide 10 mg/l

Total dissolved sulfur after 3rd injection = 104.0 + 18.0 = 122.0mg
Precipitated sulfur in this injection = 20.0 mg
Total accumulative precipitated sulfur = 30.0 + 20.0 = 50.0 mg
Total sulfur in reactor = 122.0 + 50.0 = 172.0 mg

Mass balance for 4th injection synthesized wastewater

Before injection

1. Residual sulfide in the reactor = 52.0 mg/l = 52.0 x 2 = 104 mg
2. Residual sulfate in the reactor = 9.0 mg/l = 9.0 x 2 = 18.0 mg
3. Synthesized wastewater = 10.0 mg/l = 10.0 x 2 = 20.0 mg

Total dissolved sulfur when injection = 104 + 18.0 + 20.0 =142.0 mg
Total accumulative precipitated sulfur = 50.0 mg

After 4th injection (1day)

1. Residual sulfide in the reactor = 52.0 mg/l = 52.0 x 2 = 104 mg
2. Residual sulfate in the reactor = 9.0 mg/l. = 9.0 x 2 = 18.0 mg
3. Precipitate with Zn in synthesized wastewater= 10.0 mg/l = 10.0 x 2 = 20.0 mg

*zinc 20 ppm in synthesis wastewater and all of them precipitate with sulfide in the reactor.

Then Zinc 20 mg/l precipitate with sulfide 10 mg/l

Total dissolved sulfur after 4th injection = 104.0 + 18.0 = 122.0 mg
Precipitated sulfur in this injection = 20.0 mg
Total accumulative precipitated sulfur = 50.0 + 20.0 = 70.0 mg
Total sulfur in reactor = 122.0 + 70.0 = 192.0 mg

Mass balance for 5th injection synthesized wastewater

Before injection

1. Residual sulfide in the reactor	= 52.0 mg/l = 52.0 x 2	= 104 mg
2. Residual sulfate in the reactor	= 9.0 mg/l = 9.0 x 2	= 18.0 mg
3. Synthesized wastewater	= 10.0 mg/l = 10.0 x 2	= 20.0 mg
Total dissolved sulfur when injection	= 122.0 + 20.0	= 142.0 mg
Total accumulative precipitated sulfur	= 70.0 mg	

After 5th injection (1day)

1. Residual sulfide in the reactor	= 52.0 mg/l = 52.0 x 2	= 104 mg
2. Residual sulfate in the reactor	= 9.0 mg/l = 9.0 x 2	= 18.0 mg
3. Precipitate with Zn in synthesized wastewater	= 10.0 mg/l = 10.0 x 2	= 20.0 mg

* zinc 20 ppm in synthesis wastewater and all of them precipitate with sulfide in the reactor.

Then Zinc 20 mg/l precipitate with sulfide 10 mg/l

Total dissolved sulfur after 5th injection	= 104.0 + 18.0	= 122.0 mg
Precipitated sulfur in this injection	= 20.0 mg	
Total accumulative precipitated sulfur	= 70.0 + 20.0	= 90.0 mg
Total sulfur in reactor	= 122.0 + 90.0	= 212.0 mg

Mass balance for 6th injection synthesized wastewater

Before injection

1. Residual sulfide in the reactor = 52.0 mg/l = 52.0 x 2 = 104 mg
2. Residual sulfate in the reactor = 9.0 mg/l = 9.0 x 2 = 18 mg
3. Synthesized wastewater = 25.0 mg/l = 25.0 x 2 = 50 mg

Total dissolved sulfur when injection = 104.0 + 18.0 + 50.0 =172.0 mg

Total accumulative precipitated sulfur = 90.0 mg

After 6th injection (1day)

1. Residual sulfide in the reactor = 44.0 mg/l = 44.0 x 2 = 88.0 mg
2. Residual sulfate in the reactor = 17.0 mg/l = 17.0 x 2 = 34.0 mg
3. Precipitate with Zn in synthesized wastewater= 25.0 mg/l = 25.0 x 2 = 50.0 mg

* zinc 50 ppm in synthesis wastewater and all of them precipitate with sulfide in the reactor.

$$Zn^{2+} + S^{2-} \text{ ---}\rightarrow ZnS$$

50 mg/65 + 25mg/32 = 75mg/97

Then Zinc 50 mg/l precipitate with sulfide 25 mg/l

Total dissolved sulfur after 6th injection = 88.0 + 34.0 = 122.0 mg

Precipitated sulfur in this injection = 50.0 mg

Total accumulative precipitated sulfur = 90.0 + 50.0 = 140.0 mg

Total sulfur in reactor = 122.0 + 140.0 = 162.0 mg

Mass balance for 7th injection synthesized wastewater

Before injection

1. Residual sulfide in the reactor = 44.0 mg/l = 44.0 x 2 = 88.0 mg
2. Residual sulfate in the reactor = 17.0 mg/l = 17.0 x 2 = 34.0 mg
3. Synthesized wastewater = 25.0 mg/l = 25.0 x 2 = 50.0 mg

Total dissolved sulfur when injection = 88.0 + 34.0 + 50.0 = 172 mg
Total accumulative precipitated sulfur = 140.0 mg

After 7th injection (1day)

1. Residual sulfide in the reactor = 44.0 mg/l = 44.0 x 2 = 88.0 mg
2. Residual sulfate in the reactor = 17.0 mg/l = 17.0 x 2 = 34.0 mg
3. Precipitate with Zn in synthesized wastewater= 25.0 mg/l = 25.0 x 2 = 50.0 mg

* zinc 50 ppm in synthesis wastewater and all of them precipitate with sulfide in the reactor.

$$Zn^{2+} + S^{2-} \dashrightarrow ZnS$$

50 mg/65 + 25mg/32 = 75mg/97

Then Zinc 50 mg/l precipitate with sulfide 25 mg/l

Total dissolved sulfur after 7th injection = 88.0 + 34.0 = 122.0 mg
Precipitated sulfur in this injection = 50.0 mg
Total accumulative precipitated sulfur =140.0 + 50.0 = 190.0 mg
Total sulfur in reactor = 122.0 + 190.0 = 312.0 mg

Mass balance for 8th injection synthesized wastewater

Before injection

1. Residual sulfide in the reactor = 44.0 mg/l = 44.0 x 2 = 88.0 mg
2. Residual sulfate in the reactor = 17.0 mg/l = 17.0 x 2 = 34.0 mg
3. Synthesized wastewater = 50.0 mg/l = 50.0 x 2 =100.0 mg

Total dissolved sulfur when injection = 88.0 + 34.0 + 100.0 =222.0 mg
Total accumulative precipitated sulfur = 190.0 mg

After 8th injection (1day)

1. Residual sulfide in the reactor = 40.0 mg/l = 40.0 x 2 = 80.0 mg
2. Residual sulfate in the reactor = 29.0 mg/l = 29.0 x 2 = 58.0 mg
3. Precipitate with Zn in synthesized wastewater= 42.0 mg/l = 42.0 x 2 = 84.0 mg

* zinc 100 ppm in synthesis wastewater and 85% of them precipitate with sulfide in the reactor.

$$Zn^{2+} + S^{2-} \dashrightarrow ZnS$$

85 mg/65 + 42.5mg/32 = 127.5mg/97

Then Zinc 85 mg/l precipitate with sulfide 42.5 mg/l

Total dissolved sulfur after 8th injection = 80.0 + 58.0 = 138.0 mg
Precipitated sulfur in this injection = 84.0 mg
Total accumulative precipitated sulfur = 190.0 + 84.0 = 274.0 mg
Total sulfur in reactor = 138.0 + 274.0 = 412.0 mg

Mass balance for 9th injection synthesized wastewater

Before injection

1. Residual sulfide in the reactor = 40.0 mg/l = 40.0 x 2 = 80.0 mg
2. Residual sulfate in the reactor = 29.0 mg/l = 29.0 x 2 = 58.0 mg
3. Synthesized wastewater = 50.0 mg/l = 50.0 x 2 = 100.0mg

Total dissolved sulfur when injection = 80.0 + 58.0 + 100.0 =238.0 mg
Total accumulative precipitated sulfur = 274.0 mg

After 9th injection (1day)

1. Residual sulfide in the reactor = 0.0 mg/l = 0.0 x 2 = 0.0 mg
2. Residual sulfate in the reactor = 71.0 mg/l = 71.0 x 2 = 142.0 mg
3. Precipitate with Zn in synthesized wastewater= 48.0 mg/l = 48.0 x 2 = 96.0 mg

* zinc 115 ppm in the reactor and 74.78% of them precipitate with sulfide in the reactor.

$Zn^{2+} + S^{2-} \dashrightarrow ZnS$

96 mg/65 + 48mg/32 = 129.5mg/97

Then Zinc 96 mg/l precipitate with sulfide 48 mg/l

Total dissolved sulfur after 9th injection = 142.0 + 0.0 = 142.0 mg
Precipitated sulfur in this injection = 96.0 mg
Total accumulative precipitated sulfur = 274.0 + 96.0 = 370.0 mg
Total sulfur in reactor = 142.0 + 370.0 = 512.0 mg

APPENDIX L

Temperature during the start up reactors and operation reactors

Table L-1 Temperature during the start up reactors and operation reactors

Temperature(Degree C^{o})

date	day	First reactor	Second reactor
20/2/2005	1	31.1	31.2
21/2/2005	2	31.2	31.0
22/2/2005	3	30.0	30.0
23/2/2005	4	30.8	30.7
24/2/2005	5	30.0	30.2
25/2/2005	6	30.4	30.6
26/2/2005	7	31.7	31.7
27/2/2005	8	31.3	31.1
28/2/2005	9	30.2	30.1
1/3/2005	10	31.1	31.1
2/3/2005	11	30.2	30.0
3/3/2005	12	33.2	33.5
4/3/2005	13	29.5	29.7
5/3/2005	14	27.3	27.4
6/3/2005	15	26.6	26.7
7/3/2005	16	28.1	28.1
8/3/2005	17	29.5	29.6
9/3/2005	18	30.2	30.2
10/3/2005	19	31.1	31.0
11/3/2005	20	31.5	31.5
12/3/2005	21	30.5	30.4
13/3/2005	22	30.9	30.9
14/3/2005	23	31.9	32.0
15/3/2005	24	31.0	30.8
16/3/2005	25	28.4	28.4
17/3/2005	26	30.4	30.3
18/3/2005	27	29.8	29.9
19/3/2005	28	30.2	30.1
20/3/2005	29	34.5	33.9
21/3/2005	30	31.5	
22/3/2005	31	31.1	
23/3/2005	32	30.8	
24/3/2005	33	30.9	
25/3/2005	34	29.8	
26/3/2005	35	32.2	

APPENDIX M

Zinc during the start up reactors, operation reactors and every injection the synthesized wastewater

Table M-1 Zinc during the start up reactor, operation reactors and every injection the synthesized wastewater.

Zn (mg/L,ppm)

	day	Reactor1
20/2/2005	1	0.25
28/2/2005	9	0.15
1/3/2005	10	0.18
2/3/2005	11	0.16
3/3/2005	12	0.10
4/3/2005	13	0.02
5/3/2005	14	0.08
6/3/2005	15	0.06
7/3/2005	16	0.04
8/3/2005	17	0.13
9/3/2005	18	0.10
10/3/2005	19	0.12
11/3/2005	20	0.08
12/3/2005	21	0.15
13/3/2005	22	0.30
14/3/2005	23	0.35
15/3/2005	24	0.13
16/3/2005	25	0.07
17/3/2005	26	0.14
18/3/2005	27	0.17
19/3/2005	28	0.15
20/3/2005	29	0.28
21/3/2005	30	0.09
22/3/2005	31	0.23
23/3/2005	32	0.45
24/3/2005	33	
25/3/2005	34	

The first of zinc injection (10ppm)

		Time	Reactor1
2-28-05	1	0 min	10.15
	2	30 min	0.17
	3	60 min	0.05
	4	90 min	0.07
	5	120 min	0.02
	6	3hr	0.05
	7	6hr	0.01
	8	9hr	0.09
	9	12hr	0.02
	10	15 hr	0.29

The second of zinc injection (20ppm)

		Time	Reactor1
14/3/2005	1	0 min.	20.08
	2	10 min.	0.34
	3	20 min.	0.27
	4	30 min.	0.25
	5	40 min	0.21
	6	50 min.	0.19
	7	60 min.	0.19

The third of zinc injection (20ppm)

		Time	Reactor1
16/3/2005	1	0 min.	20.04
	2	10 min.	0.28
	3	20 min.	0.24
	4	30 min.	0.32
	5	40 min.	0.24
	6	50 min.	0.20
	7	60 min.	0.46

The forth of zinc injection (20ppm)

		Time	Reactor1
19/3/2005	1	0 min.	20.15
	2	10 min.	0.36
	3	20 min.	0.42
	4	30 min.	0.41
	5	40 min.	0.42
	6	50 min.	0.41
	7	60 min.	0.41

The fifth of zinc injection (20ppm)

		Time	Reactor1
20/3/2005	1	0 min.	20.28
	2	10 min.	0.28
	3	20 min.	0.38
	4	30 min.	0.37
	5	40 min.	0.36
	6	50 min.	0.35
	7	60 min.	0.43

The sixth of zinc injection (50ppm)

		Time	Reactor1
22/3/2005	1	0 min.	50.23
	2	10 min.	0.81
	3	20 min.	0.80
	4	30 min.	0.73
	5	40 min.	0.71
	6	50 min.	0.65
	7	60 min.	0.60

The seventh of zinc injection (50ppm)

		Time	Reactor1
23/3/2005	1	0 min.	50.45
	2	10 min.	1.05
	3	20 min.	1.06
	4	30 min.	1.00
	5	40 min.	0.89
	6	50 min.	0.82
	7	60 min.	0.79

The eighth of zinc injection (100ppm)

		Time	Reactor1
24/3/2005	1	0 min.	100.5
	2	10 min.	24.2
	3	20 min.	23.1
	4	30 min.	22.1
	5	40 min.	21.0
	6	50 min.	20.1
	7	60 min.	19.0

The ninth of zinc injection (100ppm)

		Time	Reactor1
25/3/2005	1	0 min.	115.0
	2	10 min.	35.2
	3	20 min.	32.1
	4	30 min.	30.9
	5	40 min.	30.3
	6	50 min.	29.5
	7	60 min.	28.9

APPENDIX N

Zinc Mass Balance

Zinc mass balance

The 1st injection

Residual zinc	0.15	mg/l = 0.15 x 2	= 0.30 mg
Zinc injected	10	mg/l = 10 x 2	= 20 mg
Effluent	0.04	mg/l = 0.04 x 2	= 0.08 mg
The removal (precipitate)		20.30 – 0.08	= 20.22 mg
The accumulate zinc injection		0+20.0	= 20.0 mg
The accumulate zinc removal		0+20.22	= 20.22 mg

The 2nd injection

Residual zinc	0.35	mg/l = 0.35 x 2	= 0.70 mg
Zinc injected	20	mg/l = 20 x 2	= 40 mg
Effluent	0.13	mg/l = 0.13 x 2	= 0.26 mg
The removal (precipitate)		40.70-0.26	= 40.44 mg
The accumulate zinc injection		20.0+40.0	= 60.0 mg
The accumulate zinc removal		20.22+ 40.44	= 60.66 mg

The 3rd injection

Residual zinc	0.07	mg/l = 0.07 x 2	= 0.14 mg
Zinc injected	20	mg/l = 20 x 2	= 40 mg
Effluent	0.14	mg/l = 0.14 x 2	= 0.28 mg
The removal (precipitate)		40.14-0.28	= 39.86 mg
The accumulate zinc injection		60.0+40.0	= 100.0 mg
The accumulate zinc removal		60.66+ 39.86	= 100.52 mg

The 4th injection

Residual zinc 0.15 mg/l = 0.15 x 2 = 0.30 mg

Zinc injected 20 mg/l = 20 x 2 = 40 mg

Effluent 0.28 mg/l = 0.28 x 2 = 0.56 mg

The removal (precipitate) 40.30-0.56 = 39.74 mg

The accumulate zinc injection 100.0+40.0 = 140.0 mg

The accumulate zinc removal 100.52+39.74 = 140.26 mg.

The 5th injection

Residual zinc 0.28 mg/l = 0.28 x 2 = 0.56 mg

Zinc injected 20 mg/l = 20 x 2 = 40 mg

Effluent 0.09 mg/l = 0.09 x 2 = 0.18 mg

The removal (precipitate) 40.56-0.18 = 40.38 mg

The accumulate zinc injection 14.0+40.0 = 180.0 mg

The accumulate zinc removal 140.26+40.38 = 180.64 mg

The 6th injection

Residual zinc 0.23 mg/l = 0.23 x 2 = 0.46 mg

Zinc injected 50 mg/l = 50 x 2 = 100 mg

Effluent 0.45 mg/l = 0.45 x 2 = 0.90 mg

The removal (precipitate) 100.46-0.90 = 99.56 mg

The accumulate zinc injection 180.0+100.0 = 280.0 mg

The accumulate zinc removal 180.64+99.56 = 280.2 mg

The 7th injection

Residual zinc	0.45	mg/l = 0.45 x 2	= 0.90 mg
Zinc injected	50	mg/l = 50 x 2	= 100 mg
Effluent	0.52	mg/l = 0.52 x 2	= 1.04 mg
The removal (precipitate)		100.90-1.04	= 99.86 mg
The accumulate zinc injection		280.0+100.0	= 380.0 mg
The accumulate zinc removal		280.2+99.86	= 380.06 mg

The 8th injection

Residual zinc	0.52	mg/l = 0.52 x 2	= 1.04 mg
Zinc injected	100	mg/l = 100 x 2	= 200 mg
Effluent	15	mg/l = 15 x 2	= 30 mg
The removal (precipitate)		201.04-30	= 171.04 mg
The accumulate zinc injection		380.0+200.0	= 580.0 mg
The accumulate zinc removal		380.06+171.04	= 551.1 mg

The 9th injection

Residual zinc	15	mg/l = 15 x 2	= 30 mg
Zinc injected	100	mg/l = 100 x 2	= 200 mg
Effluent	19	mg/l = 19 x 2	= 38 mg
The removal (precipitate)		230-38	= 192.0 mg
The accumulate zinc injection		580.0+200.0	= 780.0 mg
The accumulate removal		551.1+192	= 743.1mg

APPENDIX O

The comparison zinc precipitation from Zinc balance and Sulfur balance

The comparison zinc precipitation from Zinc balance and Sulfur balance

1st Injection

From Zinc Balance

Precipitated zinc = 10.106 mg/l = 20.212 mg

Use S^{2-} for precipitate = 10.106 x 32/65 x 2 = 9.95 mg

From Sulfur balance

Precipitated sulfide = 5.0 mg/l x 2 = 10.0 mg

Removed zinc = 5.0 x 65/32 x 2 = 20.312 mg

2nd Injection

From Zinc Balance

Precipitated zinc = 20.218 mg/l x 2 = 40.436 mg

Use S^{2-} for precipitate = 20.218 x 32/65 x 2 = 19.906 mg

From Sulfur balance

Precipitated sulfide = 10.0 mg/l x 2 = 20.0 mg

Removed zinc = 10.0 x 65/32 x 2 = 40.626 mg

3rd Injection

From Zinc Balance

Precipitated zinc = 19.932 mg/l x 2 = 39.864 mg

Use S^{2-} for precipitate = 19.932 x 32/65 x 2 = 19.625 mg

From Sulfur balance

Precipitated sulfide = 10.0 mg/l x 2 = 20.0 mg

Removed zinc = 10.0 x 65/32 x 2 = 40.626 mg

4th Injection

From Zinc Balance

Precipitated zinc = 19.87 mg/l x 2 = 39.74 mg

Use S^{2-} for precipitate = 19.87 x 32/65 x 2 = 19.564 mg

From Sulfur balance

Precipitated sulfide = 10.0 mg/l x 2 = 20.0 mg

Removed zinc = 10.0 x 65/32 x 2 = 40.626 mg

5th Injection

From Zinc Balance

Precipitated zinc = 20.189 mg/l x 2 = 40.378 mg

Use S^{2-} for precipitate = 20.189 x 32/65 x 2 = 18.78 mg

From Sulfur balance

Precipitated sulfide = 10.0 mg/l x2 = 20.0 mg

Removed zinc = 10.0 x 65/32 x 2 = 40.626 mg

6th Injection

From Zinc Balance

Precipitated zinc = 49.776 mg/l x 2 = 99.552 mg

Use S^{2-} for precipitate = 49.776 x 32/65 x 2 = 49.01 mg

From Sulfur balance

Precipitated sulfide = 25.0 mg/l x 2 = 50.0 mg

Removed zinc = 25.0 x 65/32 x 2 = 101.562 mg

7th Injection

From Zinc Balance

Precipitated zinc = 49.933 mg/l x 2 = 99.866 mg

Use S^{2-} for precipitate = 49.933 x 32/65 x 2 = 49.164 mg

From Sulfur balance

Precipitated sulfide = 25.0 mg/l x 2 = 50.0 mg

Removed zinc = 25.0 x 65/32 x 2 = 101.562 mg

8th Injection

From Zinc Balance

Precipitated zinc = 85.523 mg/l x2 = 171.046 mg

Use S^{2-} for precipitate = 85.523 x 32/65 = 42.104 mg

From Sulfur balance

Precipitated sulfide = 42.0 mg/l x 2 = 84.0 mg

Removed zinc = 42.0 x 65/32 x 2 = 170.626 mg

9th Injection

From Zinc Balance

Precipitated zinc = 96.0 mg/l x 2 = 192.0 mg

Use S^{2-} for precipitate = 96.0 x 32/65 x 2 = 94.52 mg

From Sulfur balance

Precipitated sulfide = 48.0 mg/l x 2 = 96.0 mg

Removed zinc = 48.0 x 65/32 x 2 = 195.0 mg

Total Precipitated Zinc

From Zinc Balance = 371.547 mg/l x 2 = 743.094 mg

From Sulfur Balance = 185.0 x 65/32 x2 = 751.56 mg

APPENDIX P

The measurement and the adjustment of sulfate and sulfide from standard method of water and wastewater

4500-SO_4^{2-} E. Turbidimetric Method (Sulfate measurement)

Sampling and storage

In the presence of organic matter certain bacteria may reduce SO42- to S2-. To avoid this, stor heavily polluted or contaminated sample at 4°C

Apparatus

a. -Magnetic stirrer: Use a constant stirring speed. It is convenient to incorporate a fixed resistance in series with the motor operating the magnetic stirrer to regulate stirring speed. Use magnets of identical shape and size. The exact speed of stirring is not critical, but keep it constant for each run of samples and standards and adjust it to prevent splashing.

b. -Photometer: One of the following is required, with preference in the order given:

1). Nephelometer

2). Spectrophotometer, for use at 420 nm. Providing a light path of 2.5 to 10 cm

3). Filter photometer, equipped with a violet filter having maximum transmittance near 420 nm and providing a light path of 2.5 to 10 cm

c. –Stopwatch or electric timer

d. –Measuring spoon, capacity 0.2 to 0.3 ml

Reagent

a. Buffer solution A: Dissolve 30 g magnesium chloride, $MgCl_2.6H_2O$, 5 g Sodium acetate, $CH_3COONa.3H_2O$, 1.0 g potassium nitrate, KNO_3, and 20 ml acetic acid, CH_3COOH (99%), in 500 ml distilled water and make up to 1000 ml

b. Buffer solution B: (required when the sample SO_4^{2-} concentration is less than 10 mg/l)Dissolve 30 g magnesium chloride, $MgCl_2.6H_2O$, 5 g Sodium acetate, $CH_3COONa.3H_2O$, 1.0 g potassium nitrate, KNO_3, 0.111 g sodium sulfate, Na_2SO_4, and 20 ml acetic acid, CH_3COOH (99%), in 500 ml distilled water and make up to 1000 ml

c. Barium chloride, $BaCl_2$, crystals, 20 to 30 mesh. In standardization, uniform turbidity is produced with this mesh range and the appropriate buffer.

d. Standard sulfate solution: Prepare a standard sulfate solution as described in 1) or 2) below; 1.00 ml = 100ug SO_4^{2-}

   1) Dilute 10.4 ml standard 0.0200 N H_2SO_4 titrant specified in alkalinity, Section 2320B.3c, to 100ml with distilled water.
   2) Dissolve 0.1479 g anhydrous Na_2SO_4 in distilled water and dilute to 1000 ml

Procedure

a. Formation of barium sulfate turbidity: Measure 100 ml sample or a suitable portion made up to 100 ml, into a 250 ml Erlenmeyer flask. Add 20 ml buffer solution and mix in stirring apparatus. While stirring, add a spoonful of $BaCl_2$ crystals and begin timing immediately. Stir for 60±2s at constant speed.

b. Measurement of barium sulfate turbidity: After stirring period has ended, pour solution into absorption cell of photometer and measure turbidity at 5 ± 0.5 min.

c. Preparation of calibration curve: Estimate SO_4^{2-} concentration in sample by comparing turbidity reading with a calibration curve prepared by carrying SO_4^{2-} standards through the entire procedure. Space standards at 5 mg/l increments in the 0 to 40 mg/l SO_4^{2-} range. Above 40 mg/l accuracy decreases and $BaSO_4$ suspensions lose stability. Check reliability of calibration curve by running a standard with every three or four samples.
d. Correction for sample color and turbidity: Correct for sample color and turbidity by running blanks to which $BaCl_2$ is not added.

* For this experiment have many adjustment

- Sample: 100ml of sample were from 10ml of real sample and made up to 100ml by distilled water.

- Calibration curve: Space standards at 1 mg/l increments in the 0 to 8 mg/l SO_4^{2-} range. (because SO_4^{2-} range in the sample not more than 80 mg/l)

4500- S^{2-} E. Iodometric Method (Sulfide measure ment)

Reagents

a. Hydrochloric acid, HCl, 6 N

b. Standard iodine solution, 0.0250 N: Dissolve 20 to 25 g KI in a little water and add 3.2 g iodine. After iodine has dissolved, dilute to 1000 ml, and standardize against 0.0250 N $Na_2S_2O_3$, using starch solution as indicator.

c. Standard sodium thiosulfate solution, 0.0250N: See Section 4500-O.C.2e.

d. Starch solution: See Section 4500-O.C.2d.

Procedure

a. Measure from a buret into a 500 ml flask an amount of iodine solution estimated to be an excess over the amount of sulfide present. Add distilled water, if necessary, to bring volume to about 20 ml. Add 2 ml 6N HCl. Pipet 200 ml sample into flask, discharging sample under solution surface. If iodine color disappears, add more iodine so that color remains. Back-titrate with $Na_2S_2O_3$ solution, adding a few drops of starch solution as end point is approached, and continuing until blue color disappears.

b. If sulfide was precipitated with zinc and ZnS filtered out return filter with precipitate to original bottle and add about 100 ml water. Add iodine solution and HCl and titrate as in 2a above.

Calculation

One milliliter 0.0250 N iodine solution reacts with 0.4 mg S^{2-}:

$$\text{mg } S^{2-}/L = \frac{[(A \times B)-(C \times D)] \times 16000}{\text{ml Sample}}$$

Where:

A = ml iodine solution.

B = normality of iodine solution

C = ml $Na_2S_2O_3$ solution, and

D = normality of $Na_2S_2O_3$ solution

* For this experiment have many adjustment

- Sample: 200ml of sample were from 10ml of real sample and made up to 200ml by distilled water.

BIOGRAPHY

Mr. Thana Techapakdivongse was born on Nov 15, 1981 in Bangkok, Thailand. He graduated from Debsirin School in Bangkok in 1999. He received his Bachelor's Degree in Environmental Engineering from Faculty of Engineer, Chulalongkorn University in 2003. He pursued his Master Degree study in the International Postgraduate Programs in Environmental Management, Inter-Department of Environmental, Chulalongkorn University, Bangkok, Thailand in May 2003. He finished his Master Degree of Science in Environment Management in May 2005.