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## APPENDICES

Table A-1 The industrial effluent standards.

Items	Units	Standard Values	Remarks
BOD (5 day, at 20 °C)	mg L <sup>-1</sup>	20	<p>Depends on physical geography or under office's consideration but not more than 60 mg L<sup>-1</sup> except</p> <p>1) Fishery canning max. 100</p> <p>2) Starch industry</p> <ul style="list-style-type: none"> <li>- Centrifugal max. 60</li> <li>- Sedimentation max. 100</li> </ul> <p>3) Noodle industry max 100</p> <p>4) Tanning industry max. 100</p> <p>5) Pulp industry max. 100</p> <p>6) Frozen food industry max. 100</p> <p>7) Industrial Estate Authorits of Thailand</p> <p>Standard values: max 1000 mg L<sup>-1</sup> per day</p>
Chemical Oxygen Demand	mg L <sup>-1</sup>	max. 120	<p>Notification of the Ministry of Industry No.2, B. E.2539 (1996).</p> <p>Depend on office's consideration but not more than 400 mg L<sup>-1</sup></p>
Chloride as Chlorine	mg L <sup>-1</sup>	max. 2000	Notification of Industrial Estate Authorits of Thailand.
Color and odour	-	none	
Cyanide as HCN	mg L <sup>-1</sup>	max. 0.2	

Table A-1 The industrial effluent standards (continued).

Items	Units	Standard Values	Remarks
Dissolved solids (DS)	mg L <sup>-1</sup>	see remarks	<p>1) Standard value: max. 2000 or under office's consideration but not more than 5000</p> <p>2) Notification of the Ministry of Industry No.2, B. E.2539 (1996). Standard value: max. 3000 or under office's consideration but not more than 5000</p> <p>3) If salinity of receiving water is higher than 2000 mg L<sup>-1</sup>, DS in the effluent should not be higher than 5000 mg L<sup>-1</sup> of the Ds in the receiving water.</p>
Formaldehyde	mg L <sup>-1</sup>	max. 1.0	<p>Notification of Industrial Estate Authorits of Thailand.</p> <p>Standard value: max 2 mg L<sup>-1</sup></p>
Free Chloride	mg L <sup>-1</sup>	max. 1.0	<p>Notification of Industrial Estate Authorits of Thailand.</p> <p>Standard value; max 5 mg L<sup>-1</sup></p>
Free ammonia	mg L <sup>-1</sup>	max. 5.0	Only of Industrial Estate Authorits of Thailand.



Table A-1 The industrial effluent standards (continued).

Items	Units	Standard Values	Remarks
Heavy metals / Cooper (Cu)	mg L <sup>-1</sup>	max. 1.0	Notification of the Ministry of Industry No.2, B. E.2539 (1996). Standard value: max. 2.0 mg L <sup>-1</sup>
Heavy metals / Asenic (As)	mg L <sup>-1</sup>	max. 0.25	Notification of Industrial Estate Authorits of Thailand. Standard value: max 1 mg L <sup>-1</sup>
Heavy metals / Barium (Ba)	mg L <sup>-1</sup>	max. 1.0	
Heavy metals / Cadmium (Cd)	mg L <sup>-1</sup>	max. 0.03	1) Zinc industry max 1.0 2) Notification of Industrial Estate Authorits of Thailand. Standard value: max 1 mg L <sup>-1</sup>
Heavy metals / Chromium (Cr)	mg L <sup>-1</sup>	max. 0.5	1) Zinc industry max 0.22 2) Notification of the Ministry of Industry No.2, B. E.2539 (1996). Standard value: Cr <sup>6+</sup> max 0.25 mg L <sup>-1</sup> Cr <sup>3+</sup> max 0.75 mg L <sup>-1</sup>
Heavy metals / Lead (Pb)	mg L <sup>-1</sup>	max. 0.2	Notification of Industrial Estate Authorits of Thailand. Standard value: max 1 mg L <sup>-1</sup>
Heavy metals / Manganese (Mn)	mg L <sup>-1</sup>	max. 5.0	1) Zinc industry max 0.02 2) Notification of Industrial Estate Authorits of Thailand. Standard value: max 10 mg L <sup>-1</sup>

Table A-1 The industrial effluent standards (continued).

Items	Units	Standard Values	Remarks
Heavy metals / Mercury (Hg)	mg L <sup>-1</sup>	max. 0.005	Zinc industry max. 2.0 mg L <sup>-1</sup>
Heavy metals / Nickel (Ni)	mg L <sup>-1</sup>	max. 0.2	1) Zinc industry max 0.2 2) Notification of Industrial Estate Authorits of Thailand. Standard value: max 1 mg L <sup>-1</sup>
Heavy metals / Selenium (Se)	mg L <sup>-1</sup>	max. 0.2	Notification of Industrial Estate Authorits of Thailand. Standard value: max 1 mg L <sup>-1</sup>
Heavy metals / Silver (Ag)	mg L <sup>-1</sup>	-	Notification of Industrial Estate Authorits of Thailand. Standard value: max 1 mg L <sup>-1</sup>
Heavy metals / Soluble iron (Fe)	mg L <sup>-1</sup>	max. 10	Only of Industrial Estate Authorits of Thailand.
Heavy metals / Zinc (Zn)	mg L <sup>-1</sup>	max. 5.0	Zinc industry max 3.0
Insecticides	mg L <sup>-1</sup>	none	
Oil & Greas	mg L <sup>-1</sup>	max. 5.0	1) Refinery & Lubricant oil industry max 15.0 2) Notification of Industrial Estate Authorits of Thailand. Standard value: max 10 mg L <sup>-1</sup>
Permanganate value	-	max. 60	
Phenol & cresols	mg L <sup>-1</sup>	max. 1.0	
Radioactivity	-	none	

Table A-1 The industrial effluent standards (continued).

Items	Units	Standard Values	Remarks
Sulphide as H <sub>2</sub> S	-	max. 1.0	Notification of Industrial Estate Authorities of Thailand. Standard value: max 5 mg L <sup>-1</sup>
Suspended solids (SS)	mg L <sup>-1</sup>	see remark	1) Standard value: depends on dilution ratio of wastewater and receiving water 2) Ratio of wastewater and receiving water 1) 1/8 to 1/150 max. 30 2) 1/151 to 1/300 max 60 3) 1/301 to 1/500 max 150 3) Notification of the Ministry of Industry No.2, B. E.2539 (1996). Standard value: max 50 mg L <sup>-1</sup> or under office's consideration but not more than 150 mg L <sup>-1</sup> 4) Notification of Industrial Estate Authorities of Thailand. Standard value: max 200 mg L <sup>-1</sup>
Synthetic detergent	mg L <sup>-1</sup>	max. 30	Only of Industrial Estate Authorities of Thailand.
Tar	mg L <sup>-1</sup>	none	Notification of Industrial Estate Authorities of Thailand. Standard value: max 10 mg L <sup>-1</sup>

Table A-1 The industrial effluent standards (continued).

Items	Units	Standard Values	Remarks
Temperature	°C	max. 40	Notification of Industrial Estate Authorits of Thailand. Standard value: max 45
Total Kjeldahl Notrogen	mg L <sup>-1</sup>	max. 100	Notification of the Ministry of Industry No.2, B. E.2539 (1996). Depend on office's consideration but not more than 200 mg L <sup>-1</sup>
Total ammomical Nitrogen as N	mg L <sup>-1</sup>	max. 50	Only of Industrial Estate Authorits of Thailand.
pH	-	5 to 9	1) Notification of the Ministry of Industry No.2, B. E.2539 (1996). Standard value: max 5.5 to 9 2) Notification of Industrial Estate Authorits of Thailand. Standard value: max 6 to 9

Table A-2 Parameters of the several compositions in the real sulfuric wastewater sample.

Portion	Chromium (mg L <sup>-1</sup> )	Iron (mg L <sup>-1</sup> )	Nickel (mg L <sup>-1</sup> )	Acidity (N)	Sulfate (g L <sup>-1</sup> )
1	0.706	295.050	0.655	0.040	1.176
2	0.707	295.100	0.658	0.040	1.178
3	0.708	295.150	0.661	0.040	1.180
Mean	0.707	295.100	0.658	0.040	1.178
SD	0.001	0.050	0.003	0	0.002
n	3	3	3	3	3

Table A-3 Effect of electric potential at 2.5 V on the removal (%) of the synthetic sulfuric wastewater sample with time.

Time (min)	Current (A)	Energy consumption (W h m <sup>-3</sup> )	Concentration			Removal rate (%)		
			Fe (mg L <sup>-1</sup> )	Acid (N)	Sulfate (g L <sup>-1</sup> )	Fe	Acid	Sulfate
0	0.11		285.61	0.040	2.40	0.00	0.00	0.00
30	0.09	62.50	215.06	0.031	1.94	24.70	19.42	19.16
60	0.08	115.65	190.06	0.028	1.84	33.46	23.30	23.21
90	0.08	165.65	167.00	0.025	1.86	41.53	30.10	22.47
120	0.07	212.50	147.28	0.023	1.68	48.43	34.95	29.84
150	0.07	256.25	129.78	0.021	1.62	54.56	38.83	32.49
180	0.06	296.90	113.67	0.018	1.46	60.20	45.63	39.02
210	0.06	334.40	98.94	0.016	1.39	65.36	48.54	41.88
240	0.06	371.90	85.06	0.014	1.32	70.22	52.43	45.00
270	0.06	409.40	72.56	0.012	1.34	74.60	57.28	44.07
300	0.05	443.75	60.33	0.010	1.23	78.88	61.17	48.51

Table A-4 Effect of electric potential at 5.0 V on the removal rate (%) of the synthetic sulfuric wastewater sample with time.

Time (min)	Current (A)	Energy consumption (W h m <sup>-3</sup> )	Concentration			Removal rate (%)		
			Fe (mg L <sup>-1</sup> )	Acid (N)	Sulfate (g L <sup>-1</sup> )	Fe	Acid	Sulfate
0	0.60		295.60	0.040	2.50	0.00	0.00	0.00
30	0.48	675.00	122.27	0.029	1.53	58.64	39.58	38.97
60	0.37	1206.75	63.93	0.019	1.07	78.37	61.46	57.15
90	0.29	1618.75	27.93	0.011	0.73	90.55	76.04	70.65
120	0.22	1937.50	5.93	0.008	0.58	97.99	83.33	76.68
150	0.16	-	-	0.005	0.47	-	90.63	81.09
180	0.14	-	-	0.003	0.44	-	93.75	82.25
210	0.11	-	-	0.003	0.42	-	93.75	83.14
240	0.10	-	-	0.003	0.41	-	94.79	83.71
270	0.10	-	-	0.002	0.40	-	94.79	83.87
300	0.09	-	-	0.002	0.39	-	94.79	84.34

Table A-5 Effect of electric potential at 7.5 V on the removal rate (%) of the synthetic sulfuric wastewater sample with time.

Time (min)	Current (A)	Energy consumption (W h m <sup>-3</sup> )	Concentration			Removal rate (%)		
			Fe (mg L <sup>-1</sup> )	Acid (N)	Sulfate (g L <sup>-1</sup> )	Fe	Acid	Sulfate
0	0.91		285.92	0.040	2.30	0.00	0.00	0.00
30	0.66	1471.90	118.23	0.026	1.30	58.65	46.94	43.53
60	0.49	2250.00	65.15	0.015	0.76	77.21	69.39	66.91
90	0.34	3328.15	29.00	0.009	0.50	89.86	81.63	78.42
120	0.24	3871.88	6.69	0.004	0.40	97.66	91.84	82.55
150	0.17	-	-	0.003	0.33	-	93.88	85.61
180	0.15	-	-	0.002	0.30	-	95.92	87.05
210	0.13	-	-	0.002	0.29	-	95.92	87.41
240	0.12	-	-	0.002	0.31	-	95.92	86.44
270	0.11	-	-	0.002	0.35	-	95.92	84.89
300	0.11	-	-	0.002	0.27	-	95.92	88.13



Table A-6 Effect of initial acid concentration at 0.04 N on the removal rate (%) of the synthetic sulfuric wastewater sample with time.

Time (min)	Current (A)	Energy consumption (W h m <sup>-3</sup> )	Concentration			Removal rate (%)		
			Fe (mg L <sup>-1</sup> )	Acid (N)	Sulfate (g L <sup>-1</sup> )	Fe	Acid	Sulfate
0	0.60		295.60	0.040	2.50	0.00	0.00	0.00
30	0.48	675.00	122.27	0.029	1.53	58.64	39.58	38.97
60	0.37	1206.75	63.93	0.019	1.07	78.37	61.46	57.15
90	0.29	1618.75	27.93	0.011	0.73	90.55	76.04	70.65
120	0.22	1937.50	5.93	0.008	0.58	97.99	83.33	76.68
150	0.16	-	-	0.005	0.47	-	90.63	81.09
180	0.14	-	-	0.003	0.44	-	93.75	82.25
210	0.11	-	-	0.003	0.42	-	93.75	83.14
240	0.10	-	-	0.003	0.41	-	94.79	83.71
270	0.10	-	-	0.002	0.40	-	94.79	83.87
300	0.09	-	-	0.002	0.39	-	94.79	84.34

Table A-7 Effect of initial acid concentration at 0.10 N on the removal rate (%) of the synthetic sulfuric wastewater sample with time.

Time (min)	Current (A)	Energy consumption (W h m <sup>-3</sup> )	Concentration			Removal rate (%)		
			Fe (mg L <sup>-1</sup> )	Acid (N)	Sulfate (g L <sup>-1</sup> )	Fe	Acid	Sulfate
0	1.30		297.64	0.105	3.66	0.00	0.00	0.00
30	1.14	1525.00	174.00	0.069	2.43	41.54	34.12	33.53
60	0.96	2837.50	114.00	0.048	1.66	61.70	54.50	54.67
90	0.77	3918.75	70.36	0.032	1.05	76.36	69.67	71.27
120	0.61	4781.25	39.45	0.022	0.88	86.74	79.15	75.83
150	0.47	5456.25	20.36	0.015	0.60	88.30	85.78	83.47
180	0.37	5981.25	8.55	0.010	0.44	92.50	90.52	87.86
210	0.30	6400.00	3.09	0.010	0.36	95.61	90.52	90.18
240	0.27	-	-	0.007	0.32	-	93.36	91.27
270	0.25	-	-	0.007	0.31	-	93.36	91.53
300	0.23	-	-	0.007	0.29	-	93.36	92.11

Table A-8 Effect of other elements on the removal rate (%) of the synthetic sulfuric wastewater sample with time.

Time (min)	Current (A)	Energy consumption (W h m <sup>-3</sup> )	Concentration			Removal rate (%)		
			Fe (mg L <sup>-1</sup> )	Ni (mg L <sup>-1</sup> )	Cr (mg L <sup>-1</sup> )	Fe	Ni	Cr
0	0.83		267.13	1.50	0.05	0.00	0.00	0.00
30	0.66	931.25	168.80	0.89	0.04	36.81	41.16	28.57
60	0.49	1650.00	109.13	0.58	0.04	59.15	61.74	34.29
90	0.33	2162.50	58.80	0.34	0.03	77.99	77.48	45.71
120	0.22	2506.25	27.13	0.19	0.02	89.84	87.17	57.14
150	0.17	2750.00	5.80	0.12	0.02	97.83	92.01	68.57
180	0.14	-	-	0.07	0.02	-	92.59	57.14
210	0.12	-	-	0.01	0.02	-	98.10	65.71
240	0.11	-	-	-	0.01	-	-	74.29
270	0.10	-	-	-	0.01	-	-	82.86
300	0.09	-	-	-	-	-	-	-

Table A-9 The removal (%) of heavy metal ions in the real sulfuric wastewater sample with time.

Time (min)	Current (A)	Energy consumption (W h m <sup>-3</sup> )	Concentration			Removal rate (%)		
			Fe (mg L <sup>-1</sup> )	Ni (mg L <sup>-1</sup> )	Cr (mg L <sup>-1</sup> )	Fe	Ni	Cr
0	1.62		219.52	0.60	0.83	0.00	0.00	0.00
30	1.50	1950.00	141.74	0.45	0.57	35.43	24.65	31.97
60	1.30	3700.00	99.52	0.35	0.43	54.67	42.25	47.96
90	1.00	5137.50	64.33	0.24	0.30	70.69	59.86	63.94
120	0.70	6200.00	37.30	0.09	0.24	83.01	84.51	70.79
150	0.44	6912.50	16.93	0.07	0.19	92.29	88.03	77.64
180	0.30	7375.00	4.33	0.03	0.15	98.03	95.07	82.21
210	0.24	-	-	0.03	0.13	-	95.07	84.49
240	0.21	-	-	0.03	0.11	-	95.07	86.78
270	0.20	-	-	-	0.11	-	-	86.78
300	0.19	-	-	-	0.09	-	-	89.06

## VITA

Miss Anchalee Suwantammarong was born on May 28, 1980 in Bangkok, Thailand. She received her Bachelor degree of Science in Chemistry from Chandrakasem Rajabhat University in 2002. After that she has been a graduate student at the Inter-Department of Environmental Science Chulalongkorn University and become a member of Environmental Analysis Research Unit (EARU). She finished her postgraduate study with the Master degree of Science in 2008. The present address is 306/6 Ramkhamhaeng Road, Haumak, Bangkok, Bangkok, Thailand, 10240. Contact number is 089-2117819.