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APPENDICES

APPENDIX A

Table A-1 Adsorption kinetics of activated carbon from bituminous coal.

Time (hr)	Weight 0.01 g		Weight 0.1 g		Weight 0.4 g	
	4-Np (mg/l)	q* (mg/g)	4-Np (mg/l)	q (mg/g)	4-Np (mg/l)	q (mg/g)
0	143.45	0.00	143.04	0.00	145.65	0.00
1	136.48	104.55	102.66	62.06	88.95	21.26
2	130.50	194.25	68.21	113.73	60.48	31.94
4	125.36	271.35	48.26	143.66	44.06	38.10
6	123.54	298.65	36.47	161.34	32.02	42.61
10	122.74	310.50	30.48	170.33	27.45	44.33
15	122.50	314.25	25.45	177.87	22.45	46.20
20	122.50	314.25	23.06	181.46	18.85	47.55
25	122.50	314.25	21.75	183.42	13.56	49.53
30	122.50	314.25	20.35	185.52	9.64	51.00
36	122.50	314.25	20.15	185.82	5.47	52.57
42	122.50	314.25	20.15	185.82	2.83	53.56
48	122.50	314.25	20.15	185.82	1.54	54.04
60	122.50	314.25	20.15	185.82	1.54	54.04
72	122.50	314.25	20.15	185.82	1.54	54.04

$$*q = \frac{(\text{4-NP concentration at 0 min(mg/l)} - \text{4-NP concentration at designated time(mg/l)})*0.15}{\text{weight of GAC (g)}}$$

Table A-2 Adsorption kinetics of activated carbon from palm shell.

Time (hr)	Weight 0.01 g		Weight 0.1 g		Weight 0.4 g	
	4-Np (mg/l)	q (mg/g)	4-Np (mg/l)	q (mg/g)	4-Np (mg/l)	q (mg/g)
0	144.07	0.00	144.45	0.00	141.58	0.00
1	138.16	88.65	102.01	62.06	91.46	18.79
2	132.56	172.65	69.65	113.73	78.56	23.63
4	128.45	234.30	46.68	143.66	50.68	34.08
6	126.78	259.35	41.39	161.34	39.56	38.26
10	124.75	289.80	34.61	170.33	30.45	41.67
15	123.95	301.80	29.98	177.87	25.25	43.62
20	123.95	301.80	27.35	181.46	19.54	45.77
25	123.95	301.80	27.22	183.42	14.56	47.63
30	123.95	301.80	27.15	185.52	9.48	49.54
36	123.95	301.80	26.93	185.82	3.48	51.79
42	123.95	301.80	26.93	185.82	2.98	51.98
48	123.95	301.80	26.93	185.82	2.63	52.11
60	123.95	301.80	26.93	185.82	2.55	52.14
72	123.95	301.80	26.93	185.82	2.55	52.14

$$*q = \frac{(\text{4-NP concentration at 0 min(mg/l)} - \text{4-NP concentration at designated time(mg/l)})*0.15}{\text{weight of GAC (g)}}$$

Table A-3 Adsorption kinetics of activated carbon from coconut shell.

Time (hr)	Weight 0.01 g		Weight 0.1 g		Weight 0.4 g	
	4-NP (mg/l)	q (mg/g)	4-NP (mg/l)	q (mg/g)	4-NP (mg/l)	q (mg/g)
0	145.65	0.00	143.45	0.00	142.75	0.00
1	139.52	91.95	104.01	59.16	90.56	19.59
2	134.72	163.50	72.05	107.10	67.62	28.17
4	130.65	225.00	48.75	142.05	46.56	36.07
6	126.45	288.00	41.39	153.09	36.39	39.89
10	125.10	308.25	34.61	163.26	28.45	42.86
15	125.10	308.25	29.98	170.20	23.45	44.74
20	125.10	308.25	28.12	173.00	17.95	46.80
25	125.10	308.25	27.56	173.84	12.50	48.84
30	125.10	308.25	27.30	174.23	8.45	50.36
36	125.10	308.25	27.05	174.60	4.98	51.66
42	125.10	308.25	26.81	174.96	3.52	52.21
48	125.10	308.25	26.81	174.96	2.35	52.65
60	125.10	308.25	26.81	174.96	2.35	52.65
72	125.10	308.25	26.81	174.96	2.35	52.65

$$*q = \frac{(\text{4-NP concentration at 0 min(mg/l)} - \text{4-NP concentration at designated time(mg/l)})*0.15}{\text{weight of GAC (g)}}$$

Table A-4 Adsorption Isotherm of 4-NP on activated carbon from bituminous coal.

M (g)	C_o (mg/l)	C_e (mg/l)	X/M* (mg/g)
0.01	143.04	120.66	335.67
0.02	143.04	102.22	306.19
0.05	143.04	56.25	260.37
0.10	143.04	19.65	185.07
0.20	143.04	7.56	101.61
0.40	143.04	1.51	53.07

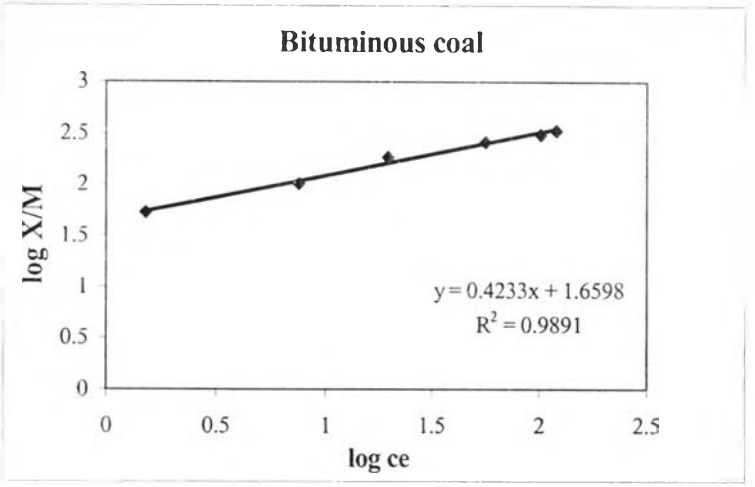
Table A-5 Adsorption Isotherm of 4-NP on activated carbon from palm shell.

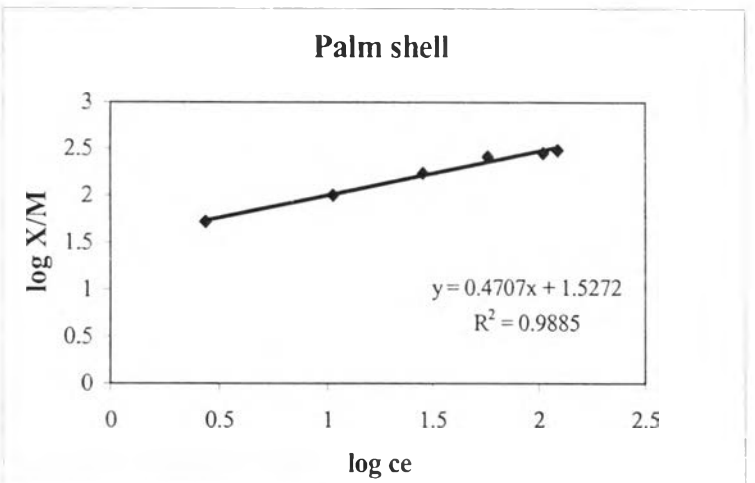
M (g)	C_o (mg/l)	C_e (mg/l)	X/M* (mg/g)
0.01	143.04	122.78	303.92
0.02	143.04	105.24	283.51
0.05	143.04	57.46	256.74
0.10	143.04	28.43	171.92
0.20	143.04	10.58	99.34
0.40	143.04	2.72	52.61

Table A-6 Adsorption Isotherm of 4-NP on activated carbon from coconut shell.

M (g)	C_o (mg/l)	C_e (mg/l)	X/M* (mg/g)
0.01	143.04	122.48	308.46
0.02	143.04	103.43	297.12
0.05	143.04	58.06	254.93
0.10	143.04	26.01	175.55
0.20	143.04	9.68	100.02
0.40	143.04	2.42	52.73

* $X/M = (C_o - C_e)*0.15/m$





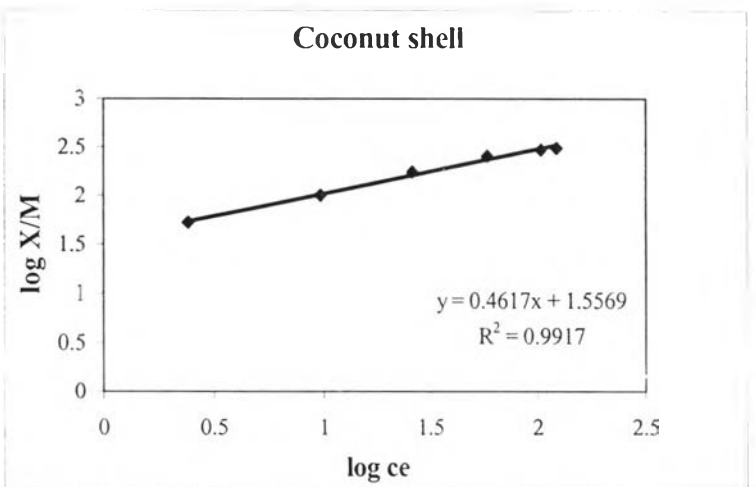
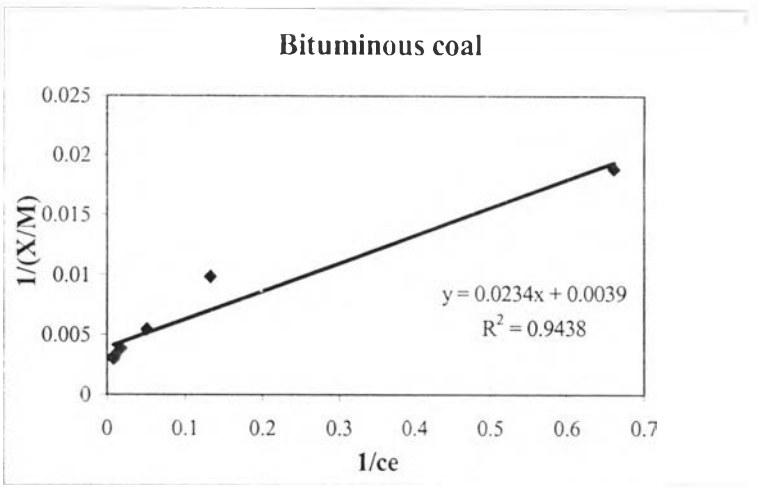
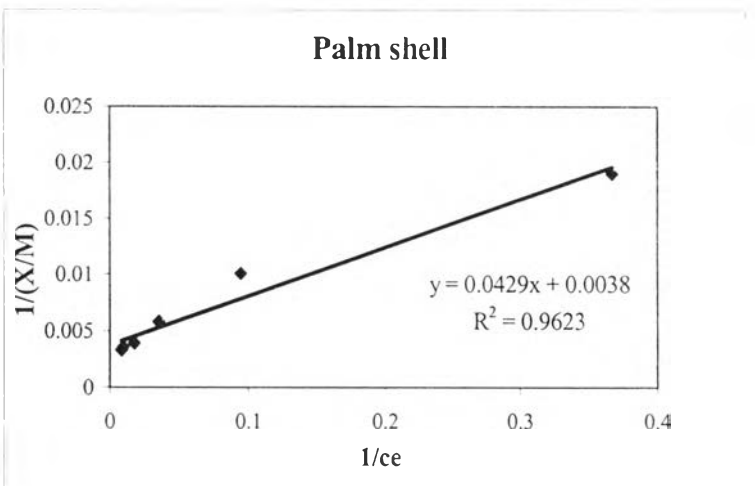


Figure A-1 Freundlich Isotherm of 4-nitrophenol on 3 types of GAC





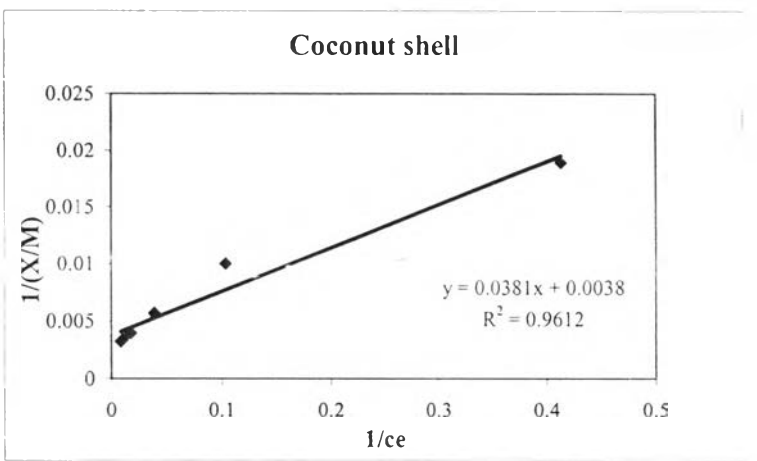


Figure A-2 Langmuir Isotherm of 4-nitrophenol on 3 types of GAC

Example A-1 Calculation of initial 4-NP concentration from adsorption isotherm in desorption experiment

This experiment want to adsorb 150 ml 4-NP solution (139.11 mg/l) into 0.1g of GAC
X/M = (139.11)*0.15/0.1 = 208.665 mg/g, so this experiment set at X/M = 210 mg/g.

From the adsorption isotherm experiment,
Initial 4-NP adsorbed on Bituminous coal X/M = 210 mg/g
Freundlich isotherm $X/M = 45.687\ Ce^{0.423}$,
Determine the C_0 value
log 210 = log 45.687 + 0.423 log Ce, So Ce = 36.81 mg/l
$X/M = 210 = (C_0\text{-}Ce)*0.15/0.1 = (C_0\text{-}36.81)*0.15/0.1$,
So C_0 = 176.81 mg/l.
From experiment data of desorption
$X/M = (C_0\text{-}Ce)*0.15/0.1 = (174.52\text{-}38.45)*0.15/0.1 = 204.10$ mg/g.

Initial 4-NP adsorbed on palm shell X/M = 210 mg/g
Freundlich isotherm $X/M = 35.416\ Ce^{0.458}$,
Determine the C_0 value
log 210 = log 35.416 + 0.458 log Ce, So Ce = 48.73 mg/l
$X/M = 210 = (C_0\text{-}Ce)*0.15/0.1 = (C_0\text{-}48.73)*0.15/0.1$,
So C_0 = 188.73 mg/l.
From experiment data of desorption
$X/M = (C_0\text{-}Ce)*0.15/0.1 = (190.30\text{-}48.80)*0.15/0.1 = 212.25$ mg/g.

Initial 4-NP adsorbed on coconut shell X/M = 210 mg/g
Freundlich isotherm $X/M = 36.050\ Ce^{0.461}$,
Determine the C_0 value
log 210 = log 36.050 + 0.461 log Ce, So Ce = 45.72 mg/l
$X/M = 210 = (C_0\text{-}Ce)*0.15/0.1 = (C_0\text{-}45.72)*0.15/0.1$,
So C_0 = 185.72 mg/l.
From experiment data of desorption
$X/M = (C_0\text{-}Ce)*0.15/0.1 = (185.43.\text{-}45.35)*0.15/0.1 = 210.12$mg/g.

Table A-7 Desorption of 4-NP from 3 type of GAC using aqueous solution at 45 °C.

Time (hr)	Bituminous coal		Palm shell		Coconut shell	
	4-NP (mg/l)	q* (mg/g)	4-NP (mg/l)	q (mg/g)	4-NP (mg/l)	q (mg/g)
0.5	2.03	3.05	1.65	2.47	1.16	1.74
1	3.20	4.79	2.62	3.92	1.84	2.76
1.5	4.94	7.41	3.29	4.94	2.32	3.48
2	6.68	10.02	4.55	6.82	2.81	4.21

Table A-8 Desorption of 4-NP from bituminous coal on pH 3, 5, 7 using aqueous solution at 30 °C.

Time (hr)	pH3		pH5		pH7	
	4-NP (mg/l)	q (mg/g)	4-NP (mg/l)	q (mg/g)	4-NP (mg/l)	q (mg/g)
0.5	0.77	1.16	1.07	1.59	1.26	1.88
1	1.74	2.61	2.03	3.05	2.13	3.19
1.5	2.52	3.77	3.27	4.91	3.58	5.37
2	3.39	5.08	4.19	6.29	5.04	7.55

Table A-9 Desorption of 4-NP from bituminous coal on pH 3,5,7 using aqueous solution at 45 °C.

Time (hr)	pH3		pH5		pH7	
	4-NP (mg/l)	q (mg/g)	4-NP (mg/l)	q (mg/g)	4-NP (mg/l)	q (mg/g)
0.5	1.65	2.47	1.84	2.76	2.03	3.05
1	2.13	3.19	2.91	4.35	3.20	4.79
1.5	3.29	4.94	3.78	5.66	4.94	7.41
2	4.55	6.82	5.33	7.99	6.68	10.02

*q = Desorption of 4-Np concentration *0.15/0.1

Table A-10 Degradation of 4-NP in solution by Fenton treatment in different ratio 4-NP: H_2O_2: Fe^{2+}.

Ratio	Time (min)	Temp. (°C)	pH	H2O2 (mg/l)	4-NP (mg/l)	TOC (mg/l)	% TOC reduction	% 4NP reduction
1:20:0.5	0	30	3.00	22100	4538.74	4585	0	0
pH3	10	56	0.67	280.50	5.85	858.70	81.27	99.87
	30	56	0.65	82.87	2.92	837.40	81.74	99.94
	60	56	0.64	0	0.97	825.50	82.00	99.98
1:20:0.5	0	30	5.00	22100	4538.74	4585	0	0
pH5	10	56	0.77	359.75	7.81	928.50	79.75	99.63
	30	56	0.75	183.75	4.88	904.50	80.27	99.89
	60	56	0.73	35.25	2.92	892.50	80.64	99.94
1:20:0.5	0	30	7.00	22100	4538.74	4585	0	0
pH7	10	58	1.12	412.25	10.73	1017.19	77.81	99.76
	30	58	1.08	280.50	7.80	955.60	79.16	99.83
	60	58	1.07	70.12	2.92	927.90	80.08	99.94
1:10:0.5	0	30	3.02	11050	4538.74	4585	0	0
PH7	10	50	0.88	375.48	47.83	1452.60	68.32	98.95
	30	50	0.87	185.75	45.88	1445.70	68.47	98.99
	60	50	0.87	0	43.92	1442.30	68.54	99.03
1:5:0.5	0	30	5.08	5525	4538.74	4585	0	0
PH7	10	50	1.05	433.5	N/A	2308.9	49.64	N/A
	30	50	0.98	178.5	N/A	2237.8	51.19	N/A
	60	50	0.97	0	N/A	2185.6	52.33	N/A

Table A-11 Degradation of 4-NP in GAC by Fenton treatment in different ratio 4-NP: H_2O_2: Fe^{2+}.

Ratio	Time (min)	Temp. (°C)	pH	H_2O_2 (mg/l)	Solution		GAC			
					4-NP (mg/l)	TOC (mg/l)	4-NP extraction (mg/l)	Mass of GAC (g)	4-NP extraction (mg/g) (1)	% Reduction 4-NP in GAC (2)
1:20:2	0	30	3.08	22100	0	0	15.72	0.0326	72.33	0
pH3	10	42.5	2	14.87	0.96	14.95	19.28	0.0580	49.87	31.05
	30	42.5	1.97	0	0	15.86	15.72	0.0490	48.12	33.46
	60	42.5	1.97	0	0.96	15.44	12.92	0.0407	47.63	34.14
	120	42.5	1.96	0	0	16.29	8.80	0.0285	46.33	35.94
1:20:1	0	30	3.02	22100	0	0	15.72	0.0326	72.33	0
pH3	10	42	2.14	44.2	0.96	15.40	12.92	0.0359	54.00	25.34
	30	42.5	2.1	5.1	0.96	15.50	11.03	0.0345	47.99	33.65
	60	42.5	2.08	0	0	16.58	15.02	0.0507	44.44	38.56
	120	42.5	2.08	0	0	16.84	8.38	0.0289	43.51	39.84

(1) 4-NP extraction (mg/g) = (4-NP extraction (mg/l)*0.15/m)

(2) % Reduction 4-NP in GAC = $\frac{\text{(4-NP extraction at time 0 min(mg/g) – 4-NP extraction at designated time(mg/g))x100}}{\text{4-NP extraction at time 0 min(mg/g)}}$

Table A-11 (next) Degradation of 4-NP in GAC by Fenton treatment in different ratio 4-NP: H_2O_2: Fe^{2+}.

Ratio	Time (min)	Temp. (°C)	pH	H_2O_2 (mg/l)	Solution		GAC			
					4-NP (mg/l)	TOC (mg/l)	4-NP extraction (mg/l)	Mass of GAC (g)	4-NP extraction (mg/g)(1)	% Reduction 4-NP in GAC (2)
1:20:0.5	0	30	3.05	22100	0	0	15.72	0.0326	72.33	0
pH3	10	42	2.43	233.75	0.96	16.90	14.64	0.0385	57.04	21.14
	30	43	2.42	23.375	0.96	16.21	17.39	0.0495	52.69	27.14
	60	43	2.4	2.125	0	17.05	16.59	0.0513	48.51	32.92
	120	43	2.41	0	0	17.86	18.89	0.0617	45.51	36.48
1:20:0.5	0	30	5.1	22100	0	0	21.73	0.0442	73.77	0
PH5	10	38	2.63	913.75	1.93	17.87	25.64	0.0769	50.01	32.20
	30	41	2.59	276.25	0.96	17.82	18.27	0.0556	49.31	33.15
	60	42	2.48	29.75	0.96	18.45	18.81	0.0615	45.87	37.81
	120	42	2.47	2.125	0	18.56	18.89	0.0681	41.62	43.57

(1) 4-NP extraction (mg/g) = (4-NP extraction (mg/l)*0.15/m)

(2) % Reduction 4-NP in GAC = $\frac{\text{(4-NP extraction at time 0 min(mg/g) – 4-NP extraction at designated time(mg/g))x100}}{\text{4-NP extraction at time 0 min(mg/g)}}$

Table A-11 (next) Degradation of 4-NP in GAC by Fenton treatment in different ratio 4-NP: H_2O_2: Fe^{2+}.

Ratio	Time (min)	Temp. (°C)	pH	H_2O_2 (mg/l)	Solution		GAC			
					4-NP (mg/l)	TOC (mg/l)	4-NP extraction (mg/l)	Mass of GAC (g)	4-NP extraction (mg/g) (1)	% Reduction 4-NP in GAC (2)
1:20:0.1	0	30	7.05	22100	0	0	20.85	0.0442	70.76	0
PH7	10	34	5.21	1381.25	1.93	18.56	27.77	0.0863	48.27	31.78
	30	37	5.20	925.5	0.96	18.21	23.24	0.0753	46.30	34.55
	60	39	5.17	425.5	0.96	17.05	22.89	0.0798	43.03	39.19
	120	39	5.15	121.5	0	18.86	23.33	0.0856	40.89	42.21
1:20:0.25	0	30	7.07	22100	0	0	22.62	0.0448	75.75	0
PH7	10	35	4.21	1311.75	1.93	17.87	17.44	0.0428	49.75	34.32
	30	38	4.18	758.75	0.96	18.82	24.53	0.0663	45.16	40.37
	60	39	4.18	359.5	0	18.48	22.46	0.0678	40.43	46.62
	120	39	4.17	85.875	0.96	17.96	21.82	0.0710	38.42	49.27

(1) 4-NP extraction (mg/g) = (4-NP extraction (mg/l)*0.15/m)

(2) % Reduction 4-NP in GAC = $\frac{\text{(4-NP extraction at time 0 min(mg/g) – 4-NP extraction at designated time(mg/g))x100}}{\text{4-NP extraction at time 0 min(mg/g)}}$

Table A-11 (next) Degradation of 4-NP in GAC by Fenton treatment in different ratio 4-NP: H_2O_2: Fe^{2+}.

Ratio	Time (min)	Temp. (°C)	pH	H_2O_2 (mg/l)	Solution		GAC			
					4-NP (mg/l)	TOC (mg/l)	4-NP extraction (mg/l)	Mass of GAC (g)	4-NP extraction (mg/g) (1)	% Reduction 4-NP in GAC (2)
1:20:0.5	0	30	7.05	22100	0	0	21.73	0.0442	73.77	0
PH7	10	39	3.10	1198.50	1.93	16.90	21.02	0.0681	46.31	37.21
	30	42	3.08	454.75	0.96	16.21	20.23	0.0763	39.77	46.09
	60	42	3.05	227.375	0	17.15	11.97	0.0540	33.27	54.89
	120	42	3.05	44.625	0	18.86	12.24	0.0583	31.50	57.29
1:15:0.5	0	30	7.05	16575	0	0	40.37	0.0775	78.13	0
PH7	10	37	3.12	616.25	0.96	17.25	21.56	0.0675	47.91	38.68
	30	39	3.05	257.25	0.96	17.95	27.77	0.0977	42.63	45.45
	60	39	3.07	119.00	0.96	18.65	31.67	0.122	38.94	50.15
	120	39	3.08	6.67	0	18.55	19.25	0.0778	37.12	52.49

(1) 4-NP extraction (mg/g) = (4-NP extraction (mg/l)*0.15/m)

(2) % Reduction 4-NP in GAC = $\frac{\text{(4-NP extraction at time 0 min(mg/g) – 4-NP extraction at designated time(mg/g))x100}}{\text{4-NP extraction at time 0 min(mg/g)}}$

Table A-11 (next) Degradation of 4-NP in GAC by Fenton treatment in different ratio 4-NP: H_2O_2: Fe^{2+}.

Ratio	Time (min)	Temp. (°C)	pH	H_2O_2 (mg/l)	Solution		GAC			
					4-NP (mg/l)	TOC (mg/l)	4-NP extraction (mg/l)	Mass of GAC (g)	4-NP extraction (mg/g) (1)	% Reduction 4-NP in GAC (2)
1:10:0.5	0	30	7.02	11050	0	0	31.85	0.0628	76.08	0
PH7	10	33	3.28	637.5	1.93	17.75	19.60	0.0592	49.68	34.69
	30	35	3.25	265.62	0.96	18.95	21.56	0.0723	44.73	41.20
	60	36	3.22	157.00	0	21.15	20.23	0.0728	41.68	45.21
	120	36	3.21	23.37	0	21.26	16.06	0.0637	37.81	50.29
1:5:0.5	0	30	7.04	5525	0	0	22.63	0.0437	77.66	0
PH7	10	32	3.08	195.25	1.93	17.21	24.13	0.0688	52.61	32.20
	30	32	3.06	110.00	0.96	18.25	26.44	0.0778	50.97	34.35
	60	32	3.06	19.75	0.96	19.56	26.17	0.0812	48.35	37.74
	120	32	3.05	0	0	21.26	26.88	0.0874	46.14	40.35

(1) 4-NP extraction (mg/g) = (4-NP extraction (mg/l)*0.15/m)

(2) % Reduction 4-NP in GAC = $\frac{\text{(4-NP extraction at time 0 min(mg/g) – 4-NP extraction at designated time(mg/g))x100}}{\text{4-NP extraction at time 0 min(mg/g)}}$

Table A-12 Degradation of 4-NP in GAC by Fenton treatment at ratio of 1:5:0.5 on 3 times, 1 hr per each time

Ratio	Times	Temp. (°C)	pH	H_2O_2 (mg/l)	Solution		GAC			
					4-NP (mg/l)	TOC (mg/l)	4-NP extraction (mg/l)	Mass of GAC (g)	4-NP extraction (mg/g) (1)	% Reduction 4-NP in GAC (2)
1:5:0.5	0	30	7.02	5525	0	0	36.82	0.074	74.64	0
PH7	1	32	3.28	14.875	1.93	17.75	25.73	0.082	47.06	36.93
	2	32	3.25	12.75	1.93	18.95	26.17	0.126	31.16	58.25
	3	32	3.22	12.75	0.96	16.40	19.34	0.153	18.96	74.59

(1) 4-NP extraction (mg/g) = (4-NP extraction (mg/l)*0.15/m)

(2) % Reduction 4-NP in GAC = $\frac{\text{(4-NP extraction at time 0 min(mg/g) – 4-NP extraction at designated time(mg/g))x100}}{\text{4-NP extraction at time 0 min(mg/g)}}$

Table A-13 Adsorption Isotherm of 4-NP on activated carbon from bituminous coal after once regeneration.

m (g)	C_o (mg/l)	C_e (mg/l)	X/m* (mg/g)
0.01	125.93	109.47	247.0268
0.02	125.93	95.42	228.8631
0.05	125.93	69.65	168.8501
0.10	125.93	40.78	127.7274
0.20	125.93	11.14	86.0961
0.40	125.93	2.90	46.1358

*X/m = (C0-Ce)*0.15/m

Table A-14 Reaction of H_2O_2 in Virgin GAC

Time (hr)	Temp. (°C)	pH	H_2O_2 (mg/l)	Solution	GAC			
				4-NP (mg/l)	4-NP extraction (mg/l)	Mass of GAC (g)	4-NP extraction (mg/g) (1)	% Reduction 4-NP in GAC (2)
0	30	7.02	6732	0	14.02	0.0436	48.23	0
1	30	6.70	6450	0	20.94	0.0668	47.02	2.51

(1) 4-NP extraction (mg/g) = (4-NP extraction (mg/l)*0.15/m)

(2) % Reduction 4-NP in GAC = $\frac{\text{(4-NP extraction at time 0 min(mg/g) – 4-NP extraction at designated time(mg/g))x100}}{\text{4-NP extraction at time 0 min(mg/g)}}$

Table A-15 Reaction of H_2O_2 in regenerated GAC

Time (hr)	Temp. (°C)	pH	H_2O_2 (mg/l)	Solution	GAC			
				4-NP (mg/l)	4-NP extraction (mg/l)	Mass of GAC (g)	4-NP extraction (mg/g) (1)	% Reduction 4-NP in GAC (2)
0	30	7.02	6732	0	30.04	0.082	47.07	0
1	30	6.25	5725	0	17.40	0.050	44.54	5.37

(1) 4-NP extraction (mg/g) = (4-NP extraction (mg/l)*0.15/m)

(2) % Reduction 4-NP in GAC = $\frac{(\text{4-NP extraction at time 0 min(mg/g)} - \text{4-NP extraction at designated time(mg/g)})\text{x}100}{\text{4-NP extraction at time 0 min(mg/g)}}$

Table A-16 Reaction of H_2O_2 in 4-nitrophenol solution

Time (hr)	Temp. (°C)	pH	H_2O_2 (mg/l)	Solution 4-NP (mg/l)
0	30	7.02	6732	1430
1	30	7.00	6690	1430

APPENDIX B

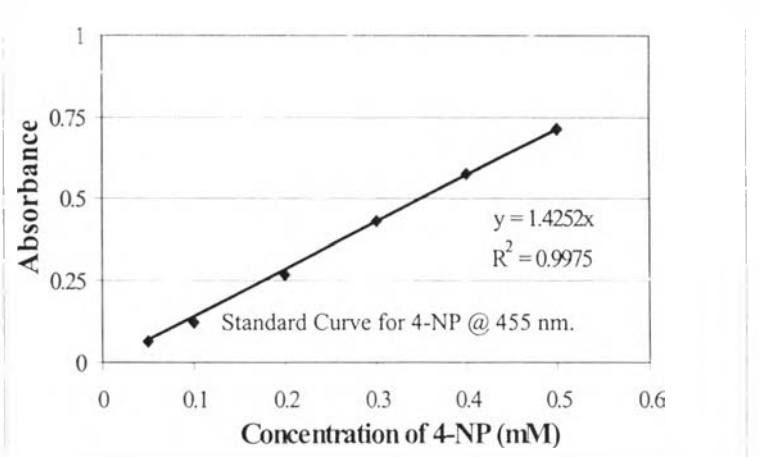
Analytical procedure for 4-nitrophenol in solution [52]

The 4-nitrophenol concentration in solution was photometrically measured at 455 nm. Previously GAC were removed from the aqueous sample by filtration (GFC) and 2 ml 0.01M NaOH was added to each 2 ml filtered solution. The sample alkalization was necessary because the adsorption coefficient of 4-nitrophenol depends on the pH value.

Table B-1 Relationship between absorbance and concentration of 4-nitrophenol at 455 nm .

4-NP (mM)	4-NP (mg/l)	Absorbance
0.05	6.956	0.066
0.1	13.911	0.125
0.2	27.822	0.265
0.3	41.733	0.432
0.4	55.644	0.575
0.5	69.555	0.718

Figure B-1 Relationship between absorbance and concentration of 4-nitrophenol at 455 nm .



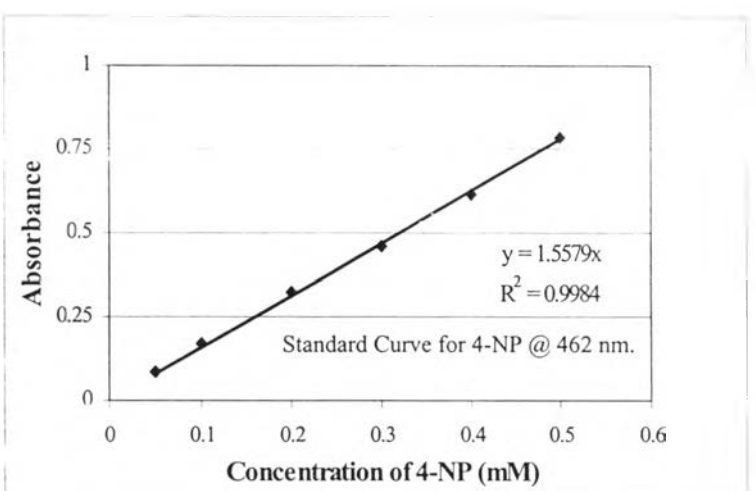
Analytical procedure for 4-nitrophenol after extraction from GAC

The 4-nitrophenol concentration after extraction from GAC by NaOH 10% was photometrically measured at 462 nm. Previous GAC were removed from the aqueous sample by filtration (GFC) and 4 ml filtered solution was added in cuvette.

Table B-2 Relationship between absorbance and concentration of 4-nitrophenol with NaOH 10% solution at 462 nm .

4-NP (mM)	4-NP (mg/l)	Absorbance
0.05	6.956	0.085
0.1	13.911	0.168
0.2	27.822	0.325
0.3	41.733	0.460
0.4	55.644	0.612
0.5	69.555	0.783

Figure B-2 Relationship between absorbance and concentration of 4-nitrophenol with NaOH 10% solution at 462 nm .



Iodometric Titration [47]

This method is used for measuring mg/l levels of H_2O_2

Reagents

1. Potassium iodide solution (KI) (1% W/V). Dissolve 1.0 grams KI into 100 ml demineralized water.
2. Ammonium molybdate solution. Dissolve 9 grams ammonium molybdate in 10 ml 6N NH_4OH Add 24 grams NH_4NO_3 and dilute to 100 ml
3. Sulfuric acid solution. Carefully add one part H_2SO_4 98% to four parts demineralized water
4. Starch indicator
5. Sodium thiosulfate solution (0.025 N)

Procedure

1. Sample was Transferred to Erlenmeyer flask.
2. 50 ml of demineralized water was added to Erlenmeyer flask. Next, 10 ml of sulfuric acid solution and 15 ml of potassium iodide solution were added. Then, 2 drops of ammonium molybdate solution was added in Erlenmeyerflask.
3. Titrate with 0.1 N sodium thiosulfate to faint yellow or straw color. Swirl or stir gently during titration to minimize iodine loss.
4. Add about 2 ml starch indicator, and continue titration until the blue color just disappears.
5. Repeat steps 2-4 on a blank sample of water

Calculation

$$H_2O_2\ (mg/l) = \frac{(A-B) \times (\text{Normality of } Na_2SO_3) \times 17 \times 1000}{ml\ ,\text{Sample}}$$

A = ml $Na_2S_2O_3$ for sample; B = ml $Na_2S_2O_3$ for blank.

BIOGRAPHY

Mr. Chalermchai Ruangchainikom was born on September 16, 1980 in Bangkok, Thailand. He attended Sathriwitthaya 2 School in Bangkok and graduated in 1996. He received his Bachelor's Degree in Environmental Engineering form Faculty of Engineering, King Mongkut's University of Technology Thonburi in 2001. He pursued his Master Degree studies in the International Postgraduate Programs in Environmental Management, Inter-Department of Environmental Management, Chulalongkorn University, Bangkok, Thailand in May 2003.