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APPENDICES



APPENDIX A

Table A.1 Dissolved oxygen concentration from respirometer setup test

No.	Test	Dissolved Oxygen concentration (mg-O ₂ /L)
1	growth medium	8.34±0.03
2	growth medium with plain beads	7.85±0.05
3	growth medium with AgNPs	8.06±0.04
4	growth medium with plain beads and AgNPs	8.30±0.05
5	AgNPs with DI	7.93±0.04
6	AgNPs with plain beads	8.46±0.05

APPENDIX B

Table B.1 Ammonia reduction and nitrate production tests

Cycle	Sample	NH ₃ concentration (mg-N/L)		NO ₃ ⁻ concentration (mg-N/L)		
		Influent	Effluent	Influent	Effluent	Production
1	Sample 1	58.9956	0.2984	39.2765	104.1667	64.8902
	Sample 2	51.7062	0.2543	26.0336	80.1034	54.0698
2	Sample 1	56.7312	0.2407	43.5724	133.0749	89.5026
	Sample 2	56.5104	0.2778	36.7248	108.8501	72.1253
3	Sample 1	55.5358	0.2190	43.6693	114.0181	70.3488
	Sample 2	50.8062	0.1979	40.6331	90.2778	49.6447
4	Sample 1	59.8366	0.3594	44.5736	97.7067	53.1331
	Sample 2	48.1006	0.1648	31.5568	84.1408	52.5840
5	Sample 1	53.4399	0.4910	36.8863	98.0297	61.1434
	Sample 2	45.1918	0.2703	27.1318	94.9612	67.8295
6	Sample 1	55.4696	0.7040	35.6912	111.7571	76.0659
	Sample 2	52.9168	0.2432	31.7183	86.0788	54.3605
7	Sample 1	51.9737	0.5754	32.4612	109.6576	77.1964
	Sample 2	54.6617	0.3502	28.1977	90.9238	62.7261
8	Sample 1	57.1176	0.1614	22.0284	74.4509	52.4225
	Sample 2	56.6762	0.1366	18.9922	68.7984	49.8062

Cycle	Sample	NH ₃ concentration (mg-N/L)			NO ₃ ⁻ concentration (mg-N/L)		
		Influent	Effluent	Reduction	Influent	Effluent	Production
9	Sample 1	52.6494	0.3328	52.3165	23.1266	87.5323	64.4057
	Sample 2	58.9179	0.2519	58.6659	24.6770	84.7868	60.1098
10	Sample 1	51.9414	0.5328	51.4086	26.2920	98.5142	72.2222
	Sample 2	60.6303	0.4349	60.1954	23.3204	90.4393	67.1189
11	Sample 1	57.0948	0.3275	56.7673	23.6434	80.5879	56.9444
	Sample 2	59.7811	0.3238	59.4573	22.7067	89.7933	67.0866
12	Sample 1	52.2788	0.7295		21.6731	75.9044	54.2313
	Sample 2	64.7899	0.3847	64.4052	22.3514	73.8049	51.4535
13	Sample 1	60.4722	0.5374	59.9348	26.2920	90.2778	63.9858
	Sample 2	65.2883	0.3089	64.9794	26.8088	96.5762	69.7674
14	Sample 1	55.2062	0.2426	54.9636	28.1331	86.8863	58.7532
	Sample 2	52.6469	0.1944	52.4525	33.8501	90.4393	56.5891
15	Sample 1	59.7512	0.1509	59.6003	34.3023	87.6938	53.3915
	Sample 2	60.2258	0.1299	60.0959	34.8837	102.0672	67.1835
16	Sample 1	59.0464	0.1583	58.8881	30.6848	77.5194	46.8346
	Sample 2	61.6723	0.1796	61.4927	31.8152	103.8437	72.0284
17	Sample 1	55.2062	0.2334	54.972829	39.6318	78.3269	38.6951

Cycle	Sample	NH ₃ concentration (mg-N/L)			NO ₃ ⁻ concentration (mg-N/L)		
		Influent	Effluent	Reduction	Influent	Effluent	Production
	Sample 2	65.9622	0.1785	65.7838	32.6550	97.3837	64.7287
18	Sample 1	47.6230	0.1522	47.4708	44.2506	84.3023	40.0517
	Sample 2	49.3708	0.2528	49.1181	38.2106	97.0607	58.8501
19	Sample 1	54.1241	0.2081	53.9160	41.1176	98.0297	56.9121
	Sample 2	55.6468	0.1748	55.4720	36.8863	103.5207	66.6344
20	Sample 1	50.7983	0.1516	50.6468	34.3346	83.0103	48.6757
	Sample 2	49.2129	0.1445	49.0683	34.9483	90.4393	55.4910
21	Sample 1	55.6468	0.1319	55.5149	35.9173	86.4018	50.4845
	Sample 2	55.8678	0.1144	55.7534	37.5000	89.1473	51.6473
22	Sample 1	55.6468	0.2254	55.4214	35.9173	83.4948	47.5775
	Sample 2	55.8678	0.1795	55.6883	37.5000	92.3773	54.8773
23	Sample 1	63.3084	1.8127	63.0830	35.8204	79.6189	43.7984
	Sample 2	67.6781	0.5944	67.4986	31.5568	91.5698	60.0129
24	Sample 1	50.4155	0.3417	48.6028	26.3889	102.0672	75.6783
	Sample 2	64.8174	0.2125	64.2230	33.6240	94.9612	61.3372

Table B.2 Dissolved oxygen concentration from free cells with ammonia concentration at 28 mg-N/L

Time (min)	0 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)		Difference	Difference	0.05 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)		Difference	Difference
10	9.43	9.46	9.45	-0.02	0.02	0.02	5.51	5.94	5.73	-0.22	0.22	
20	9.38	9.08	9.23	0.15	0.15	0.15	5.02	5.45	5.24	-0.22	0.22	
30	9.35	9.05	9.20	0.15	0.15	0.15	4.35	4.92	4.64	-0.29	0.29	
40	8.53	8.35	8.44	0.09	0.09	0.09	3.92	4.39	4.16	-0.24	0.24	
50	8.50	8.34	8.42	0.08	0.08	0.08	3.49	3.86	3.68	-0.19	0.19	
60	7.55	7.31	7.43	0.12	0.12	0.12	2.97	3.30	3.14	-0.17	0.17	
70	7.09	6.95	7.02	0.07	0.07	0.07	2.26	2.75	2.51	-0.25	0.25	
80	6.57	6.10	6.34	0.24	0.24	0.24	1.84	2.19	2.02	-0.18	0.18	
90	5.27	5.78	5.53	-0.26	0.26	0.26	0.96	1.31	1.14	-0.18	0.18	
100	4.92	4.78	4.85	0.07	0.07	0.07	0.65	0.87	0.76	-0.11	0.11	
110	3.52	3.36	3.44	0.08	0.08	0.08	0.48	0.60	0.54	-0.06	0.06	
120	3.24	3.00	3.12	0.12	0.12	0.12	0.30	0.41	0.36	-0.06	0.06	
130	2.66	1.93	2.30	0.37	0.37	0.37	0.21	0.28	0.25	-0.04	0.04	
140	1.22	1.52	1.37	-0.15	0.15	0.15	0.08	0.16	0.12	-0.04	0.04	
150	0.82	0.75	0.79	0.03	0.03	0.03	0.05	0.08	0.06	-0.02	0.02	
160	0.25	0.22	0.24	0.02	0.02	0.02	0.02	0.05	0.04	-0.02	0.02	
170	0.20	0.19	0.20	0.01	0.01	0.01		0.04	0.04	0.00	0.00	
180	0.09	0.08	0.09	0.00	0.00	0.00		0.05	0.05	0.00	0.00	
190	0.09	0.08	0.09	0.00	0.00	0.00		0.05	0.05	0.00	0.00	
200	0.08	0.07	0.08	0.01	0.01	0.01		0.04	0.04	0.00	0.00	

Time (min)	0.05 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference	1 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference
10	7.84	7.99	7.92	-0.08	0.08	8.16	6.67	7.42	0.75	0.75
20	7.51	7.63	7.57	-0.06	0.06	7.62	6.65	7.14	0.48	0.48
30	7.11	7.22	7.17	-0.05	0.05	7.60	6.65	7.13	0.48	0.48
40	6.56	6.61	6.59	-0.03	0.03	7.54	6.63	7.09	0.46	0.46
50	6.12	6.14	6.13	-0.01	0.01	7.51	6.61	7.06	0.45	0.45
60	5.51	5.49	5.50	0.01	0.01	7.49	6.58	7.04	0.46	0.46
70	5.03	4.97	5.00	0.03	0.03	7.46	6.55	7.01	0.46	0.46
80	4.37	4.27	4.32	0.05	0.05	7.42	6.46	6.94	0.48	0.48
90	3.87	3.72	3.80	0.07	0.07	7.40	6.42	6.91	0.49	0.49
100	3.18	2.98	3.08	0.10	0.10	7.38	6.37	6.88	0.51	0.51
110	2.67	2.42	2.55	0.13	0.13	7.36	6.31	6.84	0.53	0.53
120	1.98	1.69	1.84	0.15	0.15	7.34	6.19	6.77	0.58	0.58
130	1.48	1.18	1.33	0.15	0.15	7.31	6.06	6.69	0.63	0.63
140	0.89	0.63	0.76	0.13	0.13	7.28	6.01	6.65	0.64	0.64
150	0.54	0.35	0.45	0.10	0.10	7.25	5.94	6.60	0.66	0.66
160	0.25	0.12	0.19	0.07	0.07	7.22	5.86	6.54	0.68	0.68
170	0.13	0.07	0.10	0.03	0.03	6.38	5.77	6.08	0.31	0.31
180	0.05	0.05	0.05	0.00	0.00	6.35	5.72	6.04	0.32	0.32
190	0.03	0.05	0.04	-0.01	0.01	6.34	5.70	6.02	0.32	0.32
200	0.02	0.05	0.04	-0.02	0.02	6.32	5.71	6.02	0.31	0.31

Table B.3 Dissolved oxygen concentration from free cells with ammonia concentration at 70 mg-N/L

Time (min)	0 mg/L of AgNPs (mg-O ₂ /L)	Average (mg-O ₂ /L)	Diff erence	Diff erence	0.05 mg/L of AgNPs (mg-O ₂ /L)	Average (mg-O ₂ /L)	Diff erence	Diff erence	0.5 mg/L of AgNPs (mg-O ₂ /L)	Average (mg-O ₂ /L)	Diff erence	Diff erence
1	8.09	8.17	-0.08	0.08	7.30	7.74	-0.22	0.22	7.18	7.95	-0.39	0.39
10	7.86	7.95	-0.08	0.08	6.89	7.38	-0.25	0.25	6.70	7.53	-0.42	0.42
20	7.53	7.61	-0.07	0.07	6.44	6.99	-0.28	0.28	6.20	7.03	-0.42	0.42
30	7.16	7.24	-0.08	0.08	5.96	6.54	-0.29	0.29	5.66	6.48	-0.41	0.41
40	6.75	6.83	-0.08	0.08	5.42	6.06	-0.32	0.32	5.09	5.89	-0.40	0.40
50	6.31	6.39	-0.08	0.08	4.84	5.52	-0.34	0.34	4.51	5.29	-0.39	0.39
60	5.84	5.91	-0.07	0.07	4.10	4.98	-0.44	0.44	3.89	4.63	-0.37	0.37
70	5.35	5.43	-0.08	0.08	3.62	4.40	-0.39	0.39	3.27	3.99	-0.36	0.36
80	4.81	4.91	-0.10	0.10	2.99	3.80	-0.41	0.41	2.64	3.33	-0.35	0.35
90	4.25	4.35	-0.10	0.10	2.34	3.17	-0.42	0.42	2.00	2.67	-0.34	0.34
100	3.66	3.77	-0.11	0.11	1.71	2.56	-0.43	0.43	1.40	2.26	-0.43	0.43
110	3.06	3.24	-0.18	0.18	1.13	1.92	-0.40	0.40	0.88	1.61	-0.37	0.37
120	2.46	2.56	-0.10	0.10	0.66	1.33	-0.34	0.34	0.48	1.04	-0.28	0.28
130	1.85	1.93	-0.08	0.08	0.35	0.84	-0.25	0.25	0.23	0.59	-0.18	0.18
140	1.27	1.34	-0.06	0.06	0.16	0.47	-0.16	0.16	0.10	0.30	-0.10	0.10
150	0.78	0.83	-0.05	0.05	0.07	0.25	-0.09	0.09	0.05	0.16	-0.06	0.06
160	0.42	0.45	-0.03	0.03	0.03	0.12	-0.05	0.05	0.02	0.07	-0.03	0.03
170	0.20	0.22	-0.02	0.02	0.02	0.06	-0.02	0.02	0.01	0.05	-0.02	0.02
180	0.04	0.05	-0.01	0.01	0.02	0.04	-0.01	0.01				
190	0.02	0.04	-0.02	0.02								
200	0.02	0.03	-0.01	0.01								
210	0.02	0.03	-0.01	0.01								



Table B.4 Dissolved oxygen concentration from the small PVA-entrapped cells

Time (min)	0 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference	0.05 mg/L of AgNPs (mg-O ₂ /L)	Average (mg-O ₂ /L)	Difference	Difference	1 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference	
	7.71	8.08								7.90	-0.19				0.19
70	7.50	7.99	7.75	-0.25	0.25	7.79	7.85	7.82	-0.03	0.03	8.15	8.28	8.22	-0.06	0.06
140	7.26	7.94	7.60	-0.34	0.34	7.74	7.84	7.79	-0.05	0.05	8.13	8.27	8.20	-0.07	0.07
210	6.54	7.43	6.99	-0.45	0.45	7.69	7.77	7.73	-0.04	0.04	8.13	8.22	8.18	-0.04	0.04
280	6.22	6.92	6.57	-0.35	0.35	7.64	7.72	7.68	-0.04	0.04	8.09	8.06	8.08	0.01	0.01
350	6.07	6.71	6.39	-0.32	0.32	7.59	7.64	7.62	-0.02	0.02	8.06	8.00	8.03	0.03	0.03
420	5.84	6.43	6.14	-0.30	0.30	7.56	7.61	7.59	-0.03	0.03	8.06	7.99	8.03	0.04	0.04
490	5.31	5.98	5.65	-0.34	0.34	7.52	7.58	7.55	-0.03	0.03	8.05	8.02	8.04	0.02	0.02
560	4.99	5.78	5.39	-0.40	0.40	7.47	7.49	7.48	-0.01	0.01	8.02	8.03	8.03	-0.01	0.01
630	4.52	5.41	4.97	-0.45	0.45	7.45	7.47	7.46	-0.01	0.01	8.00	8.02	8.01	-0.01	0.01
700	4.16	4.95	4.56	-0.40	0.40	7.43	7.43	7.43	0.00	0.00	8.00	8.01	8.01	-0.01	0.01
770	3.63	4.25	3.94	-0.31	0.31	7.40	7.31	7.36	0.05	0.05	8.01	8.04	8.03	-0.02	0.02
840	3.29	3.87	3.58	-0.29	0.29	7.39	7.21	7.30	0.09	0.09	7.98	8.01	8.00	-0.01	0.01
910	2.79	3.37	3.08	-0.29	0.29	7.38	7.18	7.28	0.10	0.10	7.98	8.00	7.99	-0.01	0.01
980	2.49	3.00	2.75	-0.26	0.26	7.38	7.13	7.26	0.13	0.13	7.98	7.99	7.99	0.00	0.00
1050	2.22	2.76	2.49	-0.27	0.27	7.37	7.09	7.23	0.14	0.14	8.00	7.98	7.99	0.01	0.01
1120	1.87	2.46	2.17	-0.30	0.30	7.37	7.06	7.22	0.16	0.16	7.99	7.96	7.98	0.01	0.01
1190	1.74	2.38	2.06	-0.32	0.32	7.34	6.99	7.17	0.18	0.18	7.97	7.94	7.96	0.01	0.01
1260	1.66	2.33	2.00	-0.34	0.34	7.33	6.98	7.16	0.18	0.18	7.96	7.94	7.95	0.01	0.01
1330	1.65	2.33	1.99	-0.34	0.34	7.32	6.97	7.15	0.18	0.18	7.96	7.94	7.95	0.01	0.01

Table B.5 Dissolved oxygen concentration from the large PVA-entrapped cells

Time (min)	0 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)		Difference		Difference		0.5 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)		Difference		Difference	
1	7.55	7.34	7.45	7.45	0.11	0.11	0.11	0.11	7.55	7.57	7.56	7.56	-0.01	-0.01	0.01	0.01
25	7.34	7.16	7.25	7.25	0.09	0.09	0.09	0.09	7.40	7.42	7.41	7.41	-0.01	-0.01	0.01	0.01
50	7.15	6.99	7.07	7.07	0.08	0.08	0.08	0.08	7.11	7.07	7.09	7.09	0.02	0.02	0.02	0.02
75	6.98	6.83	6.91	6.91	0.08	0.08	0.08	0.08	6.72	6.69	6.71	6.71	0.01	0.01	0.01	0.01
100	6.68	6.57	6.63	6.63	0.05	0.05	0.05	0.05	6.43	6.40	6.42	6.42	0.01	0.01	0.01	0.01
125	6.38	6.30	6.34	6.34	0.04	0.04	0.04	0.04	5.92	5.93	5.93	5.93	0.00	0.00	0.00	0.00
175	6.11	6.04	6.08	6.08	0.04	0.04	0.04	0.04	5.68	5.71	5.70	5.70	-0.01	-0.01	0.01	0.01
200	5.98	5.94	5.96	5.96	0.02	0.02	0.02	0.02	5.27	5.35	5.31	5.31	-0.04	-0.04	0.04	0.04
225	5.57	5.59	5.58	5.58	-0.01	0.01	0.01	0.01	5.09	5.18	5.14	5.14	-0.04	-0.04	0.04	0.04
250	5.29	5.34	5.32	5.32	-0.03	0.03	0.03	0.03	4.90	5.01	4.96	4.96	-0.05	-0.05	0.05	0.05
275	4.99	5.09	5.04	5.04	-0.05	0.05	0.05	0.05	4.47	4.58	4.53	4.53	-0.05	-0.05	0.05	0.05
300	4.51	4.71	4.61	4.61	-0.10	0.10	0.10	0.10	4.21	4.35	4.28	4.28	-0.07	-0.07	0.07	0.07
325	4.14	4.36	4.25	4.25	-0.11	0.11	0.11	0.11	4.05	4.20	4.13	4.13	-0.08	-0.08	0.08	0.08
350	4.01	4.23	4.12	4.12	-0.11	0.11	0.11	0.11	3.73	3.90	3.82	3.82	-0.09	-0.09	0.09	0.09
375	3.87	4.09	3.98	3.98	-0.11	0.11	0.11	0.11	3.55	3.74	3.65	3.65	-0.10	-0.10	0.10	0.10
400	3.43	3.64	3.54	3.54	-0.11	0.11	0.11	0.11	3.15	3.36	3.26	3.26	-0.11	-0.11	0.11	0.11
425	3.20	3.39	3.30	3.30	-0.10	0.10	0.10	0.10	2.98	3.21	3.10	3.10	-0.12	-0.12	0.12	0.12
450	3.08	3.26	3.17	3.17	-0.09	0.09	0.09	0.09	2.82	3.04	2.93	2.93	-0.11	-0.11	0.11	0.11
475	2.90	3.09	3.00	3.00	-0.09	0.09	0.09	0.09	2.71	2.93	2.82	2.82	-0.11	-0.11	0.11	0.11
500	2.29	2.39	2.34	2.34	-0.05	0.05	0.05	0.05	2.61	2.82	2.72	2.72	-0.11	-0.11	0.11	0.11

Time (min)	1 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference	5 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference
1	7.58	7.68	7.63	-0.05	0.05	7.49	7.42	7.46	0.04	0.04
25	7.42	7.51	7.47	-0.04	0.04	7.32	7.27	7.30	0.03	0.03
50	7.20	7.33	7.27	-0.06	0.06	7.03	6.97	7.00	0.03	0.03
75	7.03	7.19	7.11	-0.08	0.08	6.70	6.64	6.67	0.03	0.03
100	6.89	7.09	6.99	-0.10	0.10	6.56	6.51	6.54	0.03	0.03
125	6.76	6.96	6.86	-0.10	0.10	6.48	6.41	6.45	0.04	0.04
175	6.65	6.85	6.75	-0.10	0.10	6.33	6.25	6.29	0.04	0.04
200	6.75	6.52	6.64	0.12	0.12	6.21	6.12	6.17	0.04	0.04
225	6.64	6.40	6.52	0.12	0.12	6.05	5.98	6.02	0.04	0.04
250	6.56	6.31	6.44	0.13	0.13	5.93	5.83	5.88	0.05	0.05
275	6.21	6.47	6.34	-0.13	0.13	5.78	5.65	5.72	0.06	0.06
300	6.12	6.39	6.26	-0.14	0.14	5.62	5.47	5.55	0.08	0.08
325	6.01	6.29	6.15	-0.14	0.14	5.45	5.30	5.38	0.08	0.08
350	5.88	6.18	6.03	-0.15	0.15	5.27	5.11	5.19	0.08	0.08
375	5.76	6.06	5.91	-0.15	0.15	5.09	4.89	4.99	0.10	0.10
400	5.66	5.95	5.81	-0.15	0.15	4.96	4.76	4.86	0.10	0.10
425	5.55	5.87	5.71	-0.16	0.16	4.80	4.56	4.68	0.12	0.12
450	5.43	5.75	5.59	-0.16	0.16	4.63	4.37	4.50	0.13	0.13
475	5.31	5.66	5.49	-0.18	0.18	4.39	4.11	4.25	0.14	0.14
500	5.20	5.54	5.37	-0.17	0.17	4.29	4.01	4.15	0.14	0.14

Table B.6 Dissolved oxygen concentration from the small CA-entrapped cells

Time (min)	0 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference	0.5 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference
1	7.58	8.52	8.05	-0.47	0.47	8.18	9.05	8.62	-0.44	0.44
40	7.54	8.23	7.89	-0.35	0.35	8.11	8.97	8.54	-0.43	0.43
120	7.53	8.16	7.85	-0.32	0.32	8.05	8.76	8.41	-0.35	0.35
160	7.41	7.86	7.64	-0.23	0.23	7.99	8.60	8.30	-0.31	0.31
200	7.35	7.75	7.55	-0.20	0.20	7.82	8.16	7.99	-0.17	0.17
240	7.27	7.73	7.50	-0.23	0.23	7.67	7.90	7.79	-0.12	0.12
280	7.05	7.45	7.25	-0.20	0.20	7.48	7.56	7.52	-0.04	0.04
320	6.98	7.39	7.19	-0.20	0.20	6.87	6.67	6.77	0.10	0.10
360	6.84	7.32	7.08	-0.24	0.24	6.60	6.33	6.47	0.14	0.14
400	6.21	6.77	6.49	-0.28	0.28	6.37	6.02	6.20	0.18	0.18
440	5.90	6.50	6.20	-0.30	0.30	6.05	5.62	5.84	0.22	0.22
480	5.30	6.29	5.80	-0.50	0.50	5.70	5.16	5.43	0.27	0.27
520	4.68	5.99	5.34	-0.66	0.66	5.44	4.97	5.21	0.24	0.24
560	4.00	5.58	4.79	-0.79	0.79	4.97	4.46	4.72	0.26	0.26
600	3.04	4.92	3.98	-0.94	0.94	4.80	4.24	4.52	0.28	0.28
640	2.39	4.42	3.41	-1.02	1.02	4.53	4.02	4.28	0.26	0.26
680	1.25	3.19	2.22	-0.97	0.97	4.31	3.84	4.08	0.23	0.23
720	0.95	2.78	1.87	-0.92	0.92	3.94	3.52	3.73	0.21	0.21
760	0.53	2.09	1.31	-0.78	0.78	3.78	3.36	3.57	0.21	0.21

Time (min)	1 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference	5 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference
1	9.37	9.05	9.21	0.16	0.16	8.29	8.46	8.38	-0.09	0.09
40	9.05	8.79	8.92	0.13	0.13	8.15	8.48	8.32	-0.16	0.16
120	8.62	8.62	8.62	0.00	0.00	8.08	8.39	8.24	-0.16	0.16
160	8.04	8.30	8.17	-0.13	0.13	8.00	8.18	8.09	-0.09	0.09
200	7.59	7.99	7.79	-0.20	0.20	7.90	8.07	7.99	-0.09	0.09
240	7.28	7.75	7.52	-0.23	0.23	7.79	7.94	7.87	-0.08	0.08
280	6.87	7.33	7.10	-0.23	0.23	7.48	7.58	7.53	-0.05	0.05
320	6.58	7.03	6.81	-0.23	0.23	7.15	7.24	7.20	-0.04	0.04
360	5.86	6.34	6.10	-0.24	0.24	6.95	7.01	6.98	-0.03	0.03
400	5.66	6.16	5.91	-0.25	0.25	6.73	6.82	6.78	-0.04	0.04
440	5.32	5.83	5.58	-0.26	0.26	6.21	6.25	6.23	-0.02	0.02
480	4.86	5.34	5.10	-0.24	0.24	5.38	5.27	5.33	0.05	0.05
520	4.17	4.51	4.34	-0.17	0.17	5.17	5.04	5.11	0.07	0.07
560	3.76	3.98	3.87	-0.11	0.11	5.00	4.83	4.92	0.09	0.09
600	3.19	3.31	3.25	-0.06	0.06	4.81	4.61	4.71	0.10	0.10
640	2.96	3.00	2.98	-0.02	0.02	4.33	4.12	4.23	0.11	0.11
680	2.46	2.36	2.41	0.05	0.05	4.06	3.76	3.91	0.15	0.15
720	2.17	2.04	2.11	0.06	0.06	3.80	3.44	3.62	0.18	0.18
760	2.00	1.83	1.92	0.09	0.09	3.33	2.97	3.15	0.18	0.18

Table B.7 Dissolved oxygen concentration from the large CA-entrapped cells

Time (min)	0 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference	0.5 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference
1	7.00	7.22	7.11	-0.11	0.11	8.05	8.11	8.08	-0.03	0.03
25	6.81	6.90	6.86	-0.04	0.04	7.78	7.87	7.83	-0.04	0.04
50	6.50	6.76	6.63	-0.13	0.13	7.18	7.26	7.22	-0.04	0.04
75	6.20	6.45	6.33	-0.13	0.13	6.98	7.09	7.04	-0.05	0.05
100	5.86	6.30	6.08	-0.22	0.22	6.17	6.35	6.26	-0.09	0.09
125	5.62	5.95	5.79	-0.17	0.17	5.79	6.01	5.90	-0.11	0.11
175	5.24	5.75	5.50	-0.26	0.26	5.00	5.31	5.16	-0.16	0.16
200	4.94	5.44	5.19	-0.25	0.25	4.68	5.03	4.86	-0.18	0.18
225	4.64	5.25	4.95	-0.31	0.31	4.13	4.51	4.32	-0.19	0.19
250	4.06	4.93	4.50	-0.44	0.44	3.83	4.25	4.04	-0.21	0.21
275	3.52	4.41	3.97	-0.45	0.45	3.18	3.65	3.42	-0.24	0.24
300	3.04	3.90	3.47	-0.43	0.43	2.91	3.38	3.15	-0.24	0.24
325	2.56	3.40	2.98	-0.42	0.42	2.01	2.47	2.24	-0.23	0.23
350	2.13	2.93	2.53	-0.40	0.40	1.80	2.25	2.03	-0.23	0.23
375	1.75	2.48	2.12	-0.37	0.37	1.39	1.81	1.60	-0.21	0.21
400	1.41	2.07	1.74	-0.33	0.33	1.27	1.68	1.48	-0.21	0.21
425	1.12	1.71	1.42	-0.30	0.30	1.08	1.40	1.24	-0.16	0.16
450	0.89	1.41	1.15	-0.26	0.26	1.00	1.30	1.15	-0.15	0.15
475	0.68	1.16	0.92	-0.24	0.24	0.89	1.14	1.02	-0.13	0.13
500	0.51	0.94	0.73	-0.22	0.22	0.82	1.05	0.94	-0.12	0.12

Time (min)	1 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference	5 mg/L of AgNPs (mg-O ₂ /L)		Average (mg-O ₂ /L)	Difference	Difference
1	8.30	8.14	8.22	0.08	0.08	8.20	8.29	8.25	-0.04	0.04
25	8.10	7.93	8.02	0.09	0.09	8.10	8.25	8.18	-0.07	0.07
50	7.98	7.80	7.89	0.09	0.09	7.95	8.10	8.03	-0.07	0.07
75	7.24	7.06	7.15	0.09	0.09	7.33	7.54	7.44	-0.11	0.11
100	6.94	6.72	6.83	0.11	0.11	7.03	7.25	7.14	-0.11	0.11
125	6.54	6.32	6.43	0.11	0.11	6.87	7.11	6.99	-0.12	0.12
175	5.91	5.68	5.80	0.12	0.12	6.27	6.56	6.42	-0.15	0.15
200	5.20	4.97	5.09	0.12	0.12	6.00	6.30	6.15	-0.15	0.15
225	4.99	4.79	4.89	0.10	0.10	5.48	5.81	5.65	-0.17	0.17
250	4.24	4.04	4.14	0.10	0.10	5.11	5.47	5.29	-0.18	0.18
275	4.05	3.86	3.96	0.10	0.10	4.96	5.34	5.15	-0.19	0.19
300	3.87	3.69	3.78	0.09	0.09	4.63	5.01	4.82	-0.19	0.19
325	3.40	3.22	3.31	0.09	0.09	4.30	4.69	4.50	-0.20	0.20
350	3.13	2.96	3.05	0.09	0.09	4.11	4.51	4.31	-0.20	0.20
375	3.00	2.85	2.93	0.07	0.07	3.84	4.24	4.04	-0.20	0.20
400	2.85	2.71	2.78	0.07	0.07	3.41	3.82	3.62	-0.21	0.21
425	2.45	2.34	2.40	0.06	0.06	3.18	3.60	3.39	-0.21	0.21
450	2.20	2.10	2.15	0.05	0.05	2.85	3.27	3.06	-0.21	0.21
475	1.87	1.78	1.83	0.05	0.05	2.54	2.96	2.75	-0.21	0.21
500	1.78	1.71	1.75	0.04	0.04	2.32	2.74	2.53	-0.21	0.21



BIOGRAPHY

Miss Chutima Ploychankul was born on December 24th, 1983 in Bangkok, Thailand. She enrolled Biochemistry class at Chulalongkorn University in 2003. During the time in, she has been joined in the International Association for the Exchange of Student for Technical Experience (IAESTE), Thailand for internship at the Max-Planck Institute of Molecular Plant Physiology, Potsdam, Germany for 6 months. After receiving B.Sc. degree in Biochemistry, she pursued her Master degree in international program in the field of Environmental and Hazardous Waste Management, Chulalongkorn University in May 2008 to October 2010. During the period, she got a chance joining an international conference, Asian-Pacific Regional Conference on Practical Environmental Technology (APRC 2010), to present her research entitled "INFLUENCE OF SILVER NANOPARTICLE ON NITRIFICATION PERFORMANCE IN WASTEWATER TREATMENT SYSTEM".

