Appendix I
Detailed Nitrogen Results

A.1 Ammonia probe results

These tables show the different mV readings taken with the ammonia probe, and the different volumes of sample collected. The majority of the condensation was collected in flask 1 which accounts for the increase in volume compared to the 100ml of boric acid that was originally in the flask. The lg(NH4+) column gives the reading of x axis in Figure A.1, and the NH4+ column showing the actual amount of ammonia in mg/l. The second table in each of the weeks (eg. Table A.2) shows the values used to plot the graph (Figure A.1) from which the ammonia values were obtained.

A.1.1 Facultative pond

(a) 6th – 13th April 2004 (Week 1)

Table A.1 Results showing amount of ammonia volatilised in week1 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	203	162	0.55	3.548134
2	98	132	-0.23	0.588844
3	98	131	-0.26	0.549541
Effluent	/	169	0.74	5.495409
Influent	/	200	1.55	35.48134

Table A.2 Results of the standards 20mg/l, 10mg/l and 1mg/l for week1 of the facultative pond

lg standards (20mg/l, 10mg/l, 1mg/l)	mV
1.301	191
1	178
0	141

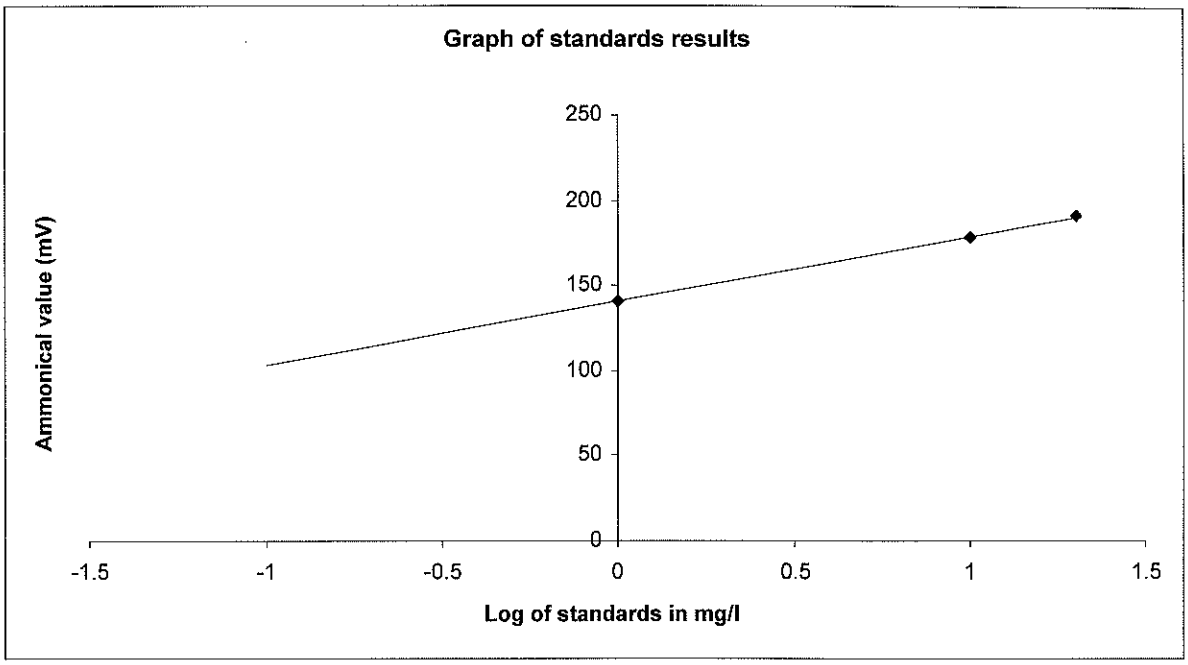

Figure A.1 Example graph of the standards which the lg(NH4+) results were taken from

(b) 15th – 20th April 2004 (Week 2)

Table A.3 Results showing amount of ammonia volatilised in week2 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	377	165	0.46	2.884032
2	95	136	-0.3	0.501187
3	95	137	-0.28	0.524807
Effluent	100	174	0.66	4.570882
Influent	100	209	1.6	39.81072

Table A.4 Results of the standards 20mg/l, 10mg/l and 1mg/l for week2 of the facultative pond

lg standards	mV
1.301	199
1	185
0	148

(c) 28th April – 5th May 2004 (Week 3)

Table A.5 Results showing amount of ammonia volatilised in week3 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+Conden	95	130	-0.26	0.549541
2	97	113	-0.66	0.218776
3	97	111	-0.71	0.194984
Effluent	100	169	0.68	4.786301
Influent	100	199	1.39	24.54709

Table A.6 Results of the standards 20mg/l, 10mg/l and 1mg/l for week3 of the facultative pond

lg(20,10,1)	mV
1.301	196
1	182
0	141

(d) 12th – 19th May 2004 (Week 4)

Table A.7 Results showing amount of ammonia volatilised in week4 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+Conden	133	147	0.1	1.258925
2	122	132	-0.28	0.524807
3	75	130	-0.31	0.489779
Effluent	100	165	0.56	3.630781
Influent	100	194	1.27	18.62087

Table A.8 Results of the standards 20mg/l, 10mg/l and 1mg/l for week4 of the facultative pond

lg standards	mV
1.301	195
1	181
0	143

(e) 20th - 26th May 2004 (Week 5)

Table A.9 Results showing amount of ammonia volatilised in week5 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+conden	137	137	-0.1	0.794328
2	100	118	-0.6	0.251189
3	98	121	-0.51	0.30903
Effluent	>	169	0.75	5.623413
Influent	>	204	1.7	50.11872

Table A.10 Results of the standards 20mg/l, 10mg/l and 1mg/l for week5 of the facultative pond

lg standards	mV
1.301	191
1	176
0	141

(f) 27th May – 2nd June 2004 (Week 6)

Table A.11 Results showing amount of ammonia volatilised in week6 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1	153	152	0.31	2.041738
2	110	122	-0.42	0.380189
3	77	120	-0.48	0.331131
Influent	/	197	1.38	23.98833
Effluent	/	165	0.6	3.981072

Table A.12 Results of the standards 20mg/l, 10mg/l and 1mg/l for week6 of the facultative pond

lg standards	mV
1.301	194
1	180
0	140

(g) 3rd – 16th June 2004 (Week 7&8)

Table A.13 Results showing amount of ammonia volatilised in week7&8 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+conden	140	152	0.22	1.659587
2	111	127	-0.41	0.389045
3	90	132	-0.28	0.524807
Effluent	>	165	0.53	3.388442
Influent	>	207	1.6	39.81072

Table A.14 Results of the standards 20mg/l, 10mg/l and 1mg/l for week7&8 of the facultative pond

lg standards	mV
1.301	195
1	183
0	143

(h) 17th – 23rd June 2004 (Week 9)

Table A.15 Results showing amount of ammonia volatilised in week9 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+conden	245	136	-0.18	0.660693
2	118	111	-0.8	0.158489
3	85	104	-0.98	0.104713
Effluent	>	146	0.09	1.230269
Influent	>	185	1.05	11.22018

Table A.16 Results of the standards 20mg/l, 10mg/l and 1mg/l for week9 of the facultative pond

lg stand	mV
1.301	195
1	183
0	143

(j) 24th – 30th June (Week 10)

Table A.17 Results showing amount of ammonia volatilised in week10 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	251	135	0	1
2	134	126	-0.19	0.645654
3	90	126	-0.19	0.645654
Effluent	/	155	0.45	2.818383
Influent	/	210	1.69	48.97788

Table A.18 Results of the standards 20mg/l, 10mg/l and 1mg/l for week10 of the facultative pond

lg standards	mV
1.301	194
1	178
0	135

(i) 1st – 7th July 2004 (Week 11)

Table A.19 Results showing amount of ammonia volatilised in week11 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	247	130	-0.19	0.645654
2	100	125	-0.32	0.478630
3	98	122	-0.37	0.426580
Effluent	/	156	0.45	2.818383
Influent	/	207	1.69	48.977882

Table A.20 Results of the standards 20mg/l, 10mg/l and 1mg/l for week11 of the facultative pond

lg standards	mV
1.301	192
1	178
0	138

(j) 27th July – 3rd August 2004 (Week 12)

Table A.21 Results showing amount of ammonia volatilised in week12 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	103	145	-0.05	0.891251
2	81	141	-0.13	0.74131
3	81	139	-0.19	0.645654
Effluent	/	182	0.79	6.16595
Influent	/	203	1.29	19.49845

Table A.22 Results of the standards 20mg/l, 10mg/l and 1mg/l for week12 of the facultative pond

lg standards	mV
1.301	207
1	186
0	148

(k) 5th – 11th August 2004 (Week 13)

Table A.23 Results showing amount of ammonia volatilised in week13 of the facultative pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	150	134	-0.17	0.676083
2	11	130	-0.25	0.562341
3	99	125	-0.38	0.416869
Effluent	/	180	0.9	7.943282
Influent	/	196	1.26	18.19701

Table A.24 Results of the standards 20mg/l, 10mg/l and 1mg/l for week13 of the facultative pond

lg standards	mV
1.301	197
1	185
0	141

A.1.2 Maturation pond

(a) 13th – 18th August 2004 (Week 14)

Table A.25 Results showing amount of ammonia volatilised in week14 of the maturation pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	90	125	-0.33	0.467735
2	116	126	-0.3	0.501187
3	73	122	-0.39	0.40738
Effluent	/	144	0.09	1.230269
Influent	/	147	0.16	1.44544

Table A.26 Results of the standards 20mg/l, 10mg/l and 1mg/l for week14 of the maturation pond

lg standards	mV
1.301	200
1	186
0	140

(b) 19th – 24th August 2004 (Week 15)

Table A.27 Results showing amount of ammonia volatilised in week15 of the maturation pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	113	146	0	1
2	98	130	-0.41	0.389045
3	98	116	-0.75	0.177828
Effluent	/	156	0.25	1.778279
Influent	/	172	0.65	4.466836

Table A.28 Results of the standards 20mg/l, 10mg/l and 1mg/l for week15 of the maturation pond

lg standards	mV
1.301	198
1	186
0	146

(c) 25th August – 1st September 2004 (Week 16)

Table A.29 Results showing amount of ammonia volatilised in week16 of the maturation pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	198	146	-0.05	0.891251
2	100	130	-0.43	0.371535
3	99	128	-0.48	0.331131
Effluent	/	151	0.09	1.230269
Influent	/	173	0.61	4.073803

Table A.30 Results of the standards 20mg/l, 10mg/l and 1mg/l for week16 of the maturation pond

lg standards	mV
1.301	202
1	189
0	148

(d) 2nd – 7th September 2004 (Week 17)

Table A.31 Results showing amount of ammonia volatilised in week17 of the maturation pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	90	136	-0.23	0.588844
2	105	133	-0.29	0.512861
3	94	135	-0.26	0.549541
Effluent	/	160	0.28	1.905461
Influent	/	192	0.94	8.709636

Table A.32 Results of the standards 20mg/l, 10mg/l and 1mg/l for week17 of the maturation pond

lg standards	mV
1.301	209
1	196
0	147

(e) 8th – 14th September 2004 (Week 18)

Table A.33 Results showing amount of ammonia volatilised in week18 of the maturation pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	247	147	-0.46	0.346737
2	129	146	-0.49	0.323594
3	100	141	-0.62	0.239883
Effluent	/	167	0.1	1.258925
Influent	/	198	0.94	8.709636

Table A.34 Results of the standards 20mg/l, 10mg/l and 1mg/l for week18 of the maturation pond

lg standards	mV
1.301	212
1	199
0	164

(f) 15th – 21st September 2004 (Week 19)

Table A.35 Results showing amount of ammonia volatilised in week19 of the maturation pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	162	138	-0.46	0.346737
2	102	134	-0.55	0.281838
3	98	134	-0.55	0.281838
Effluent	/	163	0.16	1.44544
Influent	/	190	0.83	6.76083

Table A.36 Results of the standards 20mg/l, 10mg/l and 1mg/l for week19 of the maturation pond

lg standards	mV
1.301	211
1	195
0	157

(g) 22nd – 28th September 2004 (Week 20)

Table A.37 Results showing amount of ammonia volatilised in week20 of the maturation pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	144	133	-0.34	0.457088
2	100	131	-0.39	0.40738
3	100	130	-0.4	0.398107
Effluent	/	159	0.23	1.698244
Influent	/	182	0.73	5.370318

Table A.38 Results of the standards 20mg/l, 10mg/l and 1mg/l for week20 of the maturation pond

lg standards	mV
1.301	209
1	194
0	149

(h) 28th – 5th October 2004 (Week 21)

Table A.39 Results showing amount of ammonia volatilised in week21 of the maturation pond

Sample	Volume	mV	lg(NH4+)	NH4+
1+ conden	146	135	-0.31	0.489779
2	100	133	-0.35	0.446684
3	100	132	-0.37	0.42658
Effluent	/	162	0.29	1.949845
Influent	/	182	0.73	5.370318

Table A.40 Results of the standards 20mg/l, 10mg/l and 1mg/l for week21 of the maturation pond

lg standards	mV
1.301	209
1	194
0	149

A.2 Ammonia Volatilisation Calculation Results

The following example calculation shows step by step how the ammonia volatilisation results were obtained. Tables 7.41 and 7.42 show the answers to each step of the calculations, during the different weeks of the investigation.

A.2.1 Example Calculations for ammonia lost

For example, week 2 of the facultative pond.

In flow = $0.54m^3/d$

Mean Influent conc (g/m^3) = (35.5 + 39.8 + 24.5 + 18.6 + 50.1 + 24 + 39.8 + 11.2 + 49 +49 + 19.5 + 18.2) / 12

= 31.6mg/l

Loading rate in = 31.6 _ 0.54

= 17.064g/d

Out flow = 1.83m^3/d

Effluent conc = 4.5mg/l

Loading rate out = 1.83 _ 4.5

= 8.235g/d

Total Ammonia lost = 17.06 – 8.235

= **8.829g/d**

Area of Pond B = 33.6m^2

Ammonia lost per m^2 = 8.829/33.6

= 0.2628g/m^2/d

Area of Box = 0.1122m^2 (see NB at the bottom)

Ammonia from the box = 0.2628 _ 0.1122

= 0.0295g/d

I found 2.89mg/l, 0.5mg/l and 0.52mg/l in my samples

These figures were calculated from the results recorded from the ammonia probe. Standards were used to create a standards chart (20mg/l, 10mg/l and 1 mg/l) by charting the lg of 20, 10 and 1 on the x axis against their probe results in mV on the y axis. The sample results recorded in mV from the probe were then compared with the standards trendline created on the chart, to record log values of ammonia (lg (NH^{4+})). These values were converted into ammonia values by putting them to the power of 10.

Eg. Sample jar 1:

mV	lg(NH4+)	NH4+
143	-0.125	0.749894

These results then had to be amended to account for the volume of liquid that the ammonia was collected it to work out the concentration. I did this my multiplying the mg/l value by the volume of liquid for each sample (in litres) and dividing by 1000.

Eg: (2.89 _ 0.203)/1000 + (0.5 _ 0.098)/1000 + (0.52 _ 0.095)/1000

= (0.00108953 + 0.0000475 + 0.0000494) / 5 days

= 0.00118643 / 5days

= 0.000237286 g/day

Therefore 0.237mg/day of ammonia was recorded from the sample flasks.

Amount of ammonia volatilised from whole pond = Amm/day _ (pond area /box area)

= 0.000237286 _ (33.6 / 0.1122)

= 0.071g/day

% volatilised = (Amm. volatilised from whole pond / Total Amm. Lost) _ 100

= (0.071058909 / 8.829) _ 100

% volatilised = 0.805%

NB. Due to the amendments made to the design of the box apparatus (as seen in Figure 3.5). The surface area of the box had to be reworked as follows:

Measurements were made so that the sides of the square shape I would use for the area calculations would each be the hypotenuse of 4 triangles that I could measure from the box:

$X_1 = \sqrt{34^2 + 5^2}$

$= 34.37$

$X_2 = \sqrt{33^2 + 6^2}$

$= 33.54$

$X_3 = \sqrt{34^2 + 3^2}$

$= 34.12$

$X_4 = \sqrt{33^2 + 4^2}$

$= 33.24$

Area of facultative = (33.24 _ 34.12) + ((33.54 – 33.24) _ 34.12) + (_ _ (34.37 – 34.12) - 33.54)

= 1134.15 + 10.24 + 4.19

= 1148.58

$= 1149cm^2$

Therefore from April 28th onwards $0.1149m^2$ was used as the value for the surface area.

Area of maturation = (33.06 _ 34.01) + ((33.09 – 33.06) _ 34.01) + (1/2 _ (34.03 – 34.01) _ 33.09)

$= 1124.37 + 1.02 + 0.3309$

$= 1125.72$

$= 1126cm^2$

Therefore a surface area of $0.1126m^2$ was used for the entire investigation on the maturation pond.

A.2.2 Facultative Pond

Table A.41. Results and calculations showing amount of ammonia volatilised as a percentage of total nitrogen removed from the facultative pond

	In flow m3/d	Influent Conc g/m3	Mean influent conc g/m3	Loading Rate In g/d	Out flow m3/d	Effluent Conc g/m3	Loading Rate Out g/d	Total Ammonia Lost g/d	Ammonia lost per m2 g/m2/d	Total Ammonia from the box area g/day
Week 1	0.54	35.5	31.6	17.064	1.83	5.5	10.07	6.999	0.2083036	0.0233717
Week 2	0.54	39.8	31.6	17.064	1.83	4.5	8.235	8.829	0.2627679	0.0294826
Week 3	0.54	24.5	31.6	17.064	1.83	4.79	8.766	8.298	0.2469732	0.0283772
Week 4	0.943	18.6	31.6	29.7988	2.412	3.63	8.756	21.04	0.6262869	0.0719604
Week 5	0.943	50.1	31.6	29.7988	2.412	5.62	13.56	16.24	0.4834333	0.0555465
Week 6	0.943	24	31.6	29.7988	2.412	3.98	9.6	20.2	0.6011619	0.0690735
Week 7&8	0.835	39.8	31.6	26.386	2.794	3.39	9.472	16.91	0.5034030	0.0578410
Week 9	0.835	11.2	31.6	26.386	2.794	1.23	3.437	22.95	0.6830173	0.0784787
Week 10	0.835	49	31.6	26.386	2.794	2.82	7.879	18.51	0.5508012	0.0632871
Week 11	0.835	49	31.6	26.386	2.794	2.82	7.879	18.51	0.5508012	0.0632871
Week 12	0.835	19.5	31.6	26.386	2.794	6.17	17.24	9.147	0.2722327	0.0312795
Week 13	0.835	18.2	31.6	26.386	2.794	7.94	22.18	4.202	0.1250488	0.0143681

Ammonia in jar 1 mg/l	Volume of liquid in jar 1 litres	Mass of ammonia in jar 1 g	Amm. in jar 2 mg/l	Vol. of liquid in jar 2 litres	Mass of amm. in jar 2 g	Amm. in jar 3 mg/l	Vol. of liquid in jar 3 litres	Mass of amm. in jar 3 g	No# of days	Amm/day g/day	Amm from whole pond g/day	% Volatilis
3.5	0.203	0.000711	0.59	0.098	0.0000578	0.55	0.098	0.0000539	7	0.0001175	0.035175	0.503
2.89	0.377	0.001090	0.5	0.095	0.0000475	0.52	0.095	0.0000494	5	0.0002373	0.071059	0.805
0.55	0.13	0.000072	0.22	0.113	0.0000249	0.19	0.111	0.0000211	5	0.0000235	0.006869	0.083
1.26	0.147	0.000185	0.52	0.132	0.0000686	0.49	0.13	0.0000637	5	0.0000635	0.018573	0.088
0.79	0.137	0.000108	0.25	0.118	0.0000295	0.31	0.121	0.0000375	6	0.0000292	0.008541	0.053
2.04	0.152	0.000310	0.38	0.122	0.0000464	0.33	0.12	0.0000396	6	0.0000660	0.019302	0.096
1.66	0.152	0.000252	0.39	0.127	0.0000495	0.52	0.132	0.0000686	13	0.0000285	0.008334	0.049
0.66	0.136	0.000090	0.16	0.111	0.0000178	0.1	0.104	0.0000104	6	0.0000197	0.005747	0.025
1	0.135	0.000135	0.65	0.126	0.0000819	0.65	0.126	0.0000819	6	0.0000498	0.014563	0.079
0.65	0.13	0.000085	0.48	0.125	0.0000600	0.43	0.122	0.0000525	6	0.0000328	0.009599	0.052
0.89	0.145	0.000129	0.74	0.141	0.0001043	0.65	0.139	0.0000904	6	0.0000540	0.015778	0.172
0.68	0.134	0.000091	0.56	0.13	0.0000728	0.42	0.125	0.0000525	6	0.0000361	0.010548	0.251

A.2.3 Maturation Pond

Table A.42 Results and calculations showing amount of ammonia volatilised as a percentage of total nitrogen removed from the maturation pond

	In flow m3/d	Influent Conc g/m3	Mean influent conc g/m3	Loading Rate In g/d	Out flow m3/d	Effluent Conc g/m3	Loading Rate Out g/d	Total Ammonia Lost g/d	Ammonia lost per m2 g/m2/d	Total Ammonia from the box area g/day
Week 14	0.612	1.45	5.61	3.43332	0.612	1.23	0.75276	2.68056	0.1465588	0.0165025
Week 15	0.612	4.47	5.61	3.43332	0.612	1.78	1.08936	2.34396	0.1281553	0.0144303
Week 16	0.612	4.07	5.61	3.43332	0.612	1.23	0.75276	2.68056	0.1465588	0.0165025
Week 17	0.612	8.71	5.61	3.43332	0.612	1.91	1.16892	2.2644	0.1238054	0.0139405
Week 18	0.612	8.71	5.61	3.43332	0.612	1.26	0.77112	2.6622	0.1455549	0.0163895
Week 19	0.612	6.76	5.61	3.43332	0.612	1.45	0.8874	2.54592	0.1391974	0.0156736
Week 20	0.612	5.37	5.61	3.43332	0.612	1.7	1.0404	2.39292	0.1308321	0.0147317
Week 21	0.612	5.37	5.61	3.43332	0.612	1.95	1.1934	2.23992	0.1224669	0.0137898

Ammonia in jar 1 mg/l	Volume of liquid in jar 1 litres	Mass of ammonia in jar 1 g	Amm. in jar 2 mg/l	Vol. of liquid in jar 2 litres	Mass of amm. in jar 2 g	Amm. in jar 3 mg/l	Vol. of liquid in jar 3 litres	Mass of amm. in jar 3 g	No# of days	Amm/day g/day	Amm from whole pond g/day	% Volatilise
0.468	0.09	0.0000421	0.501	0.116	0.0000581	0.407	0.073	0.0000297	5	2.5989E-05	0.0042215	0.157
1	0.113	0.0001130	0.389	0.098	0.0000381	0.178	0.098	0.0000174	5	3.3713E-05	0.0054761	0.234
0.891	0.198	0.0001764	0.372	0.1	0.0000372	0.331	0.099	0.0000328	7	3.5198E-05	0.0057174	0.213
0.589	0.09	0.0000530	0.513	0.105	0.0000539	0.55	0.094	0.0000517	5	3.1715E-05	0.0051516	0.228
0.347	0.247	0.0000857	0.324	0.129	0.0000418	0.24	0.1	0.000024	6	2.5251E-05	0.0041016	0.154
0.347	0.162	0.0000562	0.282	0.102	0.0000288	0.282	0.098	0.0000276	6	1.8769E-05	0.0030487	0.120
0.457	0.144	0.0000658	0.407	0.1	0.0000407	0.398	0.1	0.0000398	6	2.4385E-05	0.0039609	0.166
0.49	0.146	0.0000715	0.447	0.1	0.0000447	0.427	0.1	0.0000427	7	2.2706E-05	0.0036882	0.165

A.3 Sonde readings

The sonde measured a number of variables in the pond. The temperature and pH were key parameters looked at so in the following figures pH and temperature were graphed against each other to see the comparison.

A.3.1 Facultative ponds

(a) 15th – 20th April 2004 (Week 2)

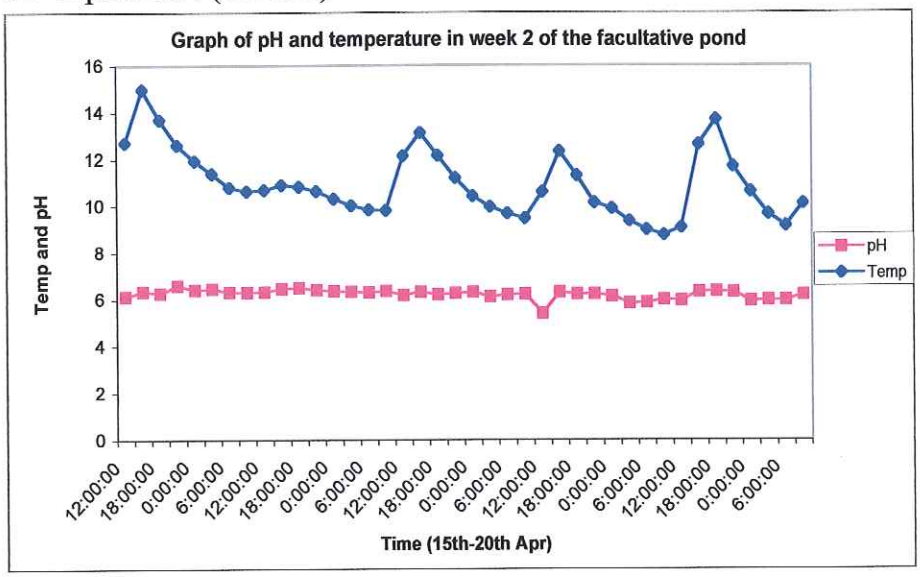

Figure A.2 Graph showing the fluctuations in pH and temperature during continuous reading in week 2

(b) 28th – 5th May 2004 (Week 3)

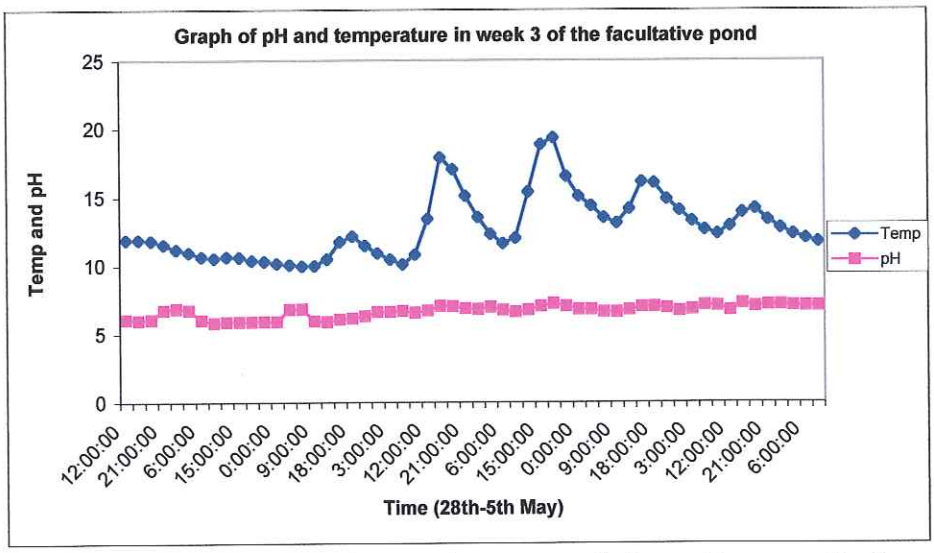

Figure A.3 Graph showing the fluctuations in pH and temperature during continuous reading in week 3

(c) 12th – 19th May 2004 (Week 4)

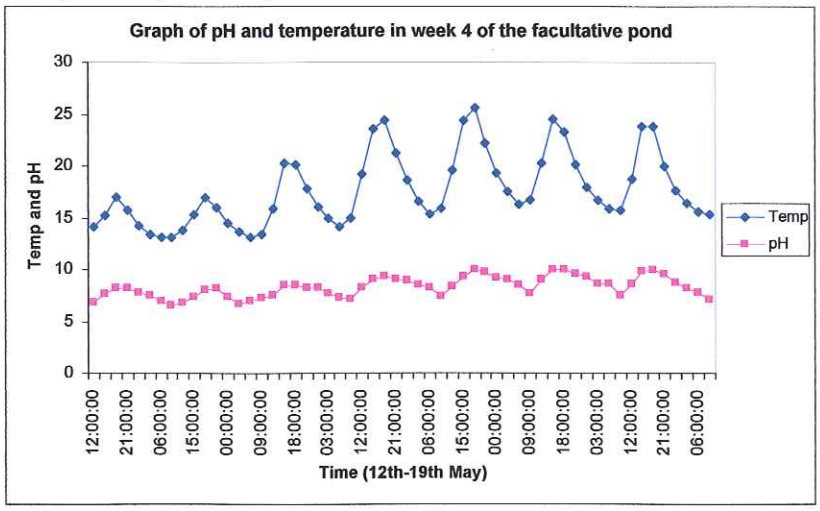

Figure A.4 Graph showing the fluctuations in pH and temperature during continuous reading in week 4

(d) 20th - 26th May 2004 (Week 5)

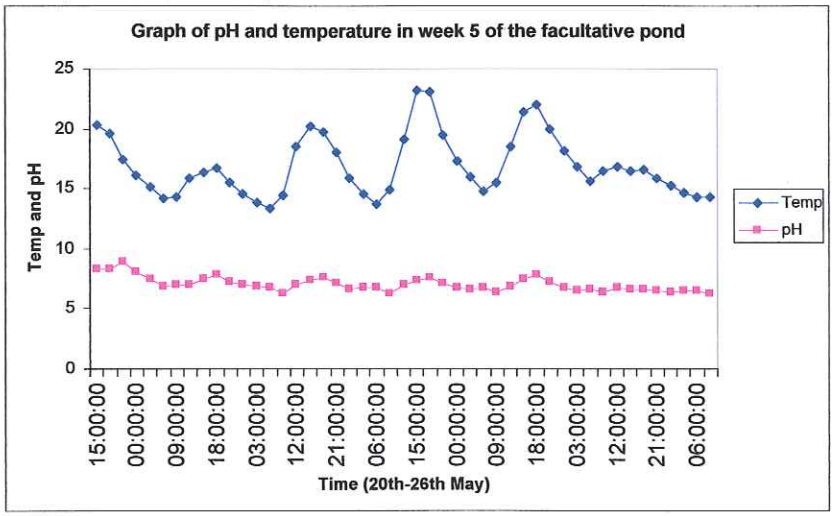

Figure A.5 Graph showing the fluctuations in pH and temperature during continuous reading in week 5

(e) 27th May – 2nd June 2004 (Week 6)

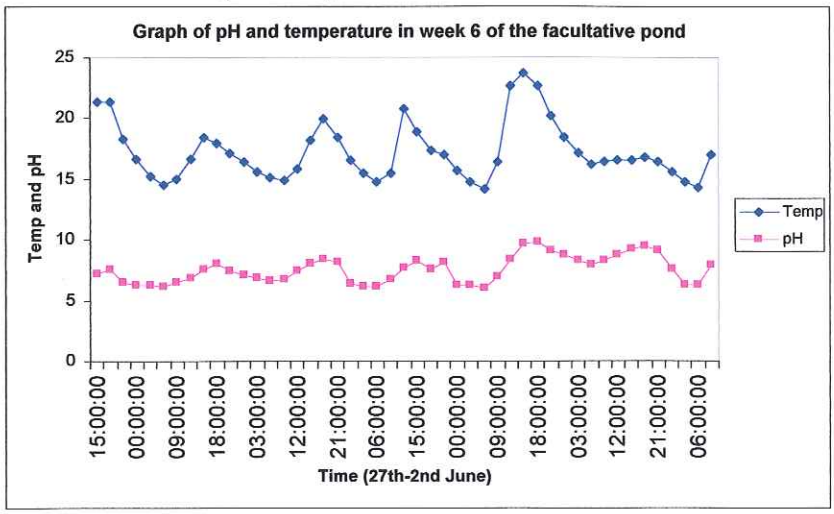

Figure A.6 Graph showing the fluctuations in pH and temperature during continuous reading in week 6

(f) 3rd – 16th June 2004 (Weeks 7&8)

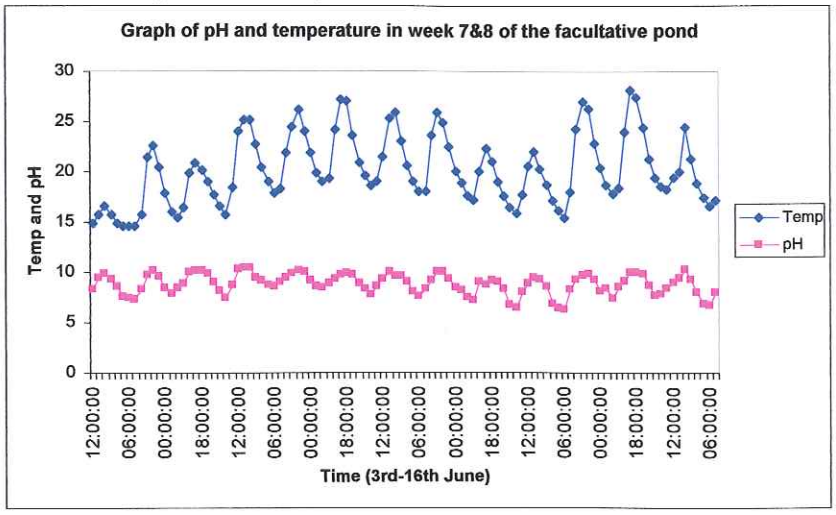

Figure A.7 Graph showing the fluctuations in pH and temperature during continuous reading in week 7&8

(g) 17th – 23rd June 2004 (Week 9)

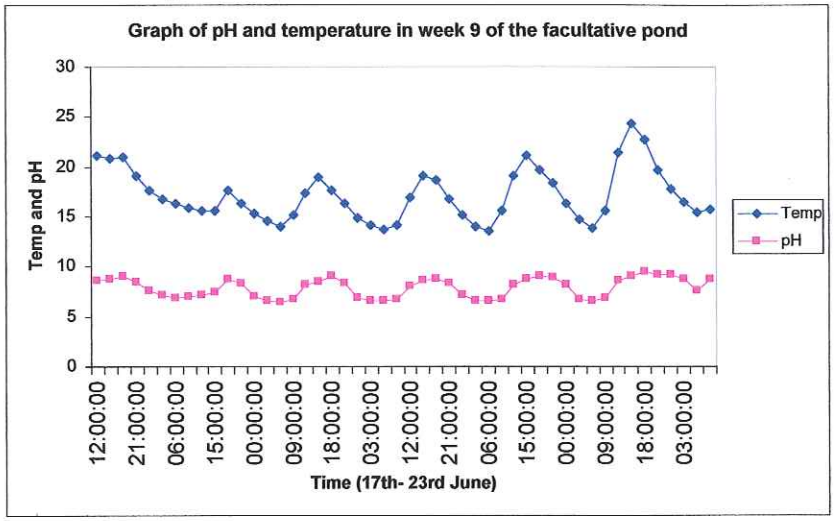

Figure A.8 Graph showing the fluctuations in pH and temperature during continuous reading in week 9

(h) 24th – 30th June (Week 10)

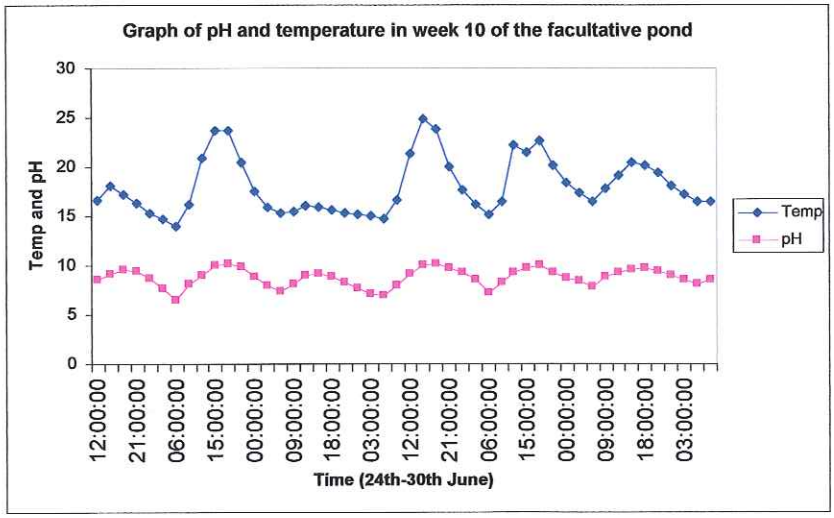

Figure A.9 Graph showing the fluctuations in pH and temperature during continuous reading in week 10

(i) 1st – 7th July 2004 (Week 11)

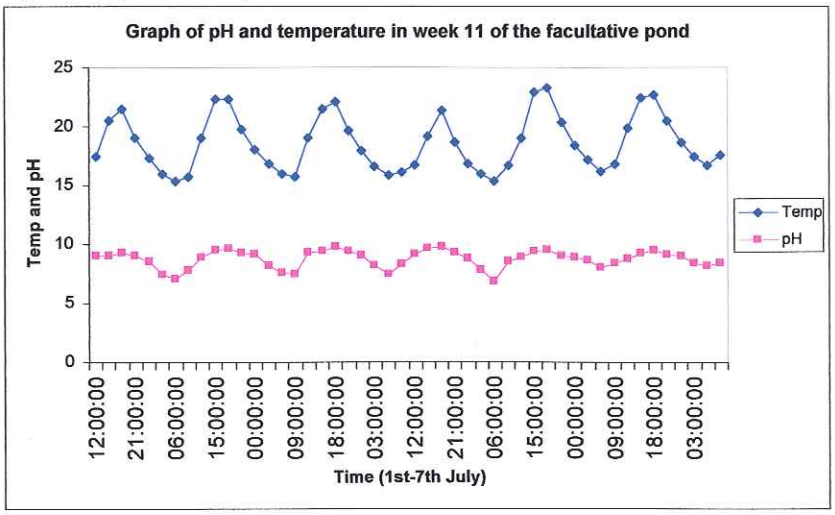

Figure A.10 Graph showing the fluctuations in pH and temperature during continuous reading in week 11

(j) 27th July – 3rd August 2004 (Week 12)

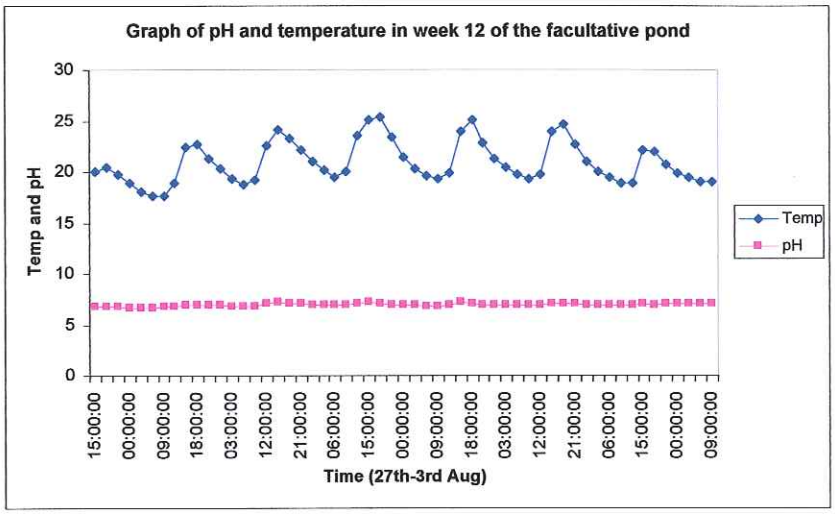

Figure A.11 Graph showing the fluctuations in pH and temperature during continuous reading in week 12

(k) 5th – 11th August 2004 (Week 13)

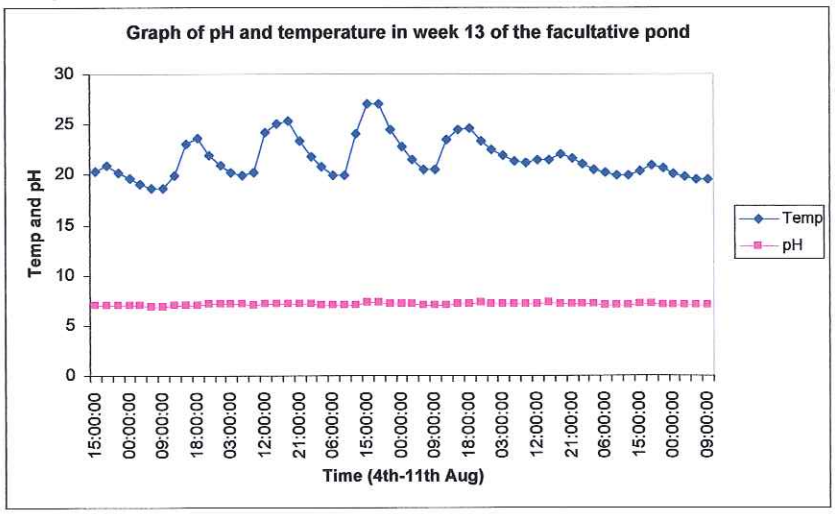

Figure A.12 Graph showing the fluctuations in pH and temperature during continuous reading in week 13

A.3.2 Maturation pond

(a) 13th – 18th August 2004 (Week 14)

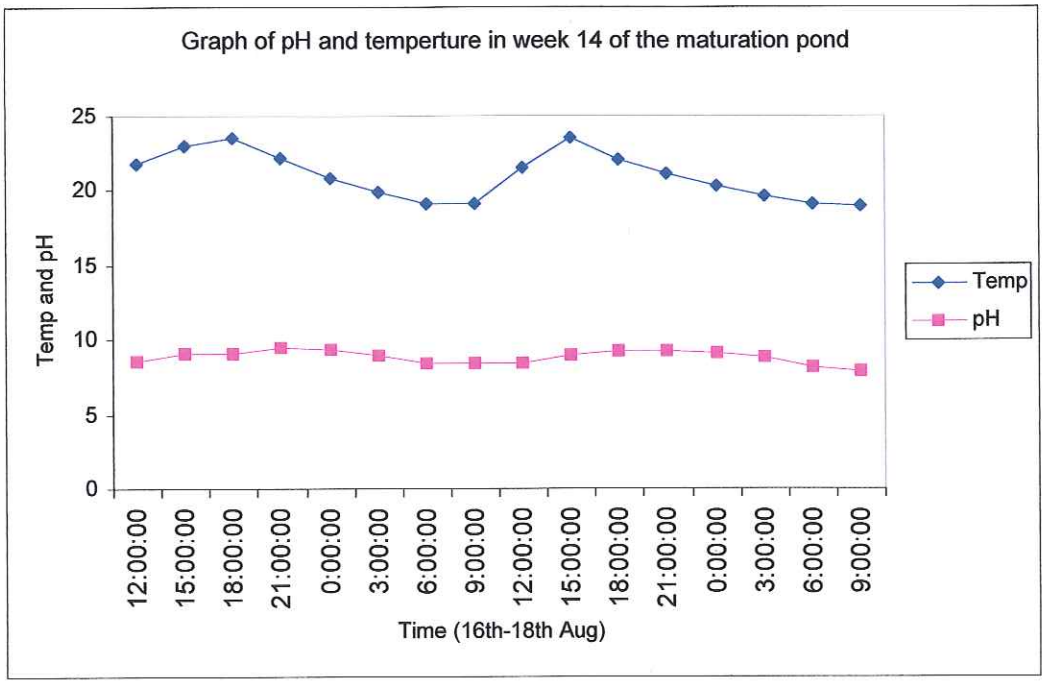

Figure A.13 Graph showing the fluctuations in pH and temperature during continuous reading in week 14

During week 14 there was a problem with recording so only 2 days of results were obtained. Although the graph looks different it is still apparent that there were diurnal variations in the temperature and slight variations in the pH, similar to the subsequent weeks.

(b) 19th – 24th August 2004 (Week 15)

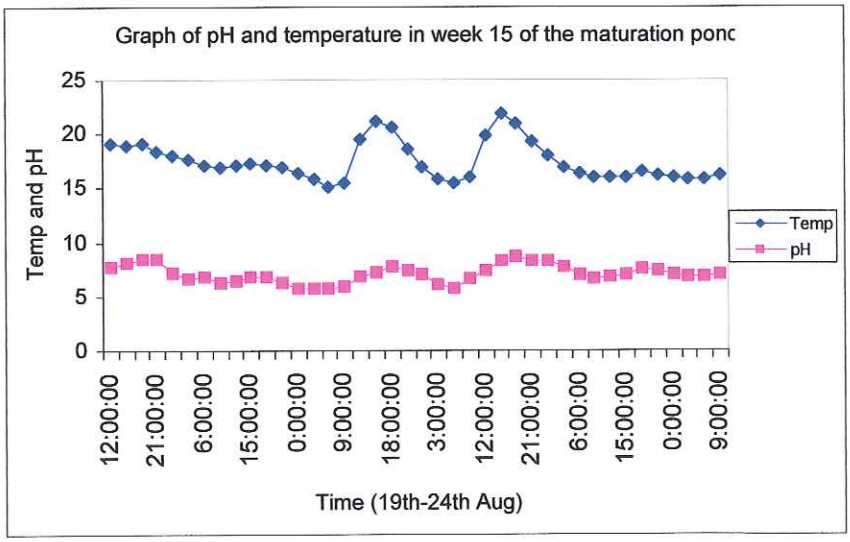

Figure A.14 Graph showing the fluctuations in pH and temperature during continuous reading in week 15

(c) 25th August – 5th September 2004 (Week 16)

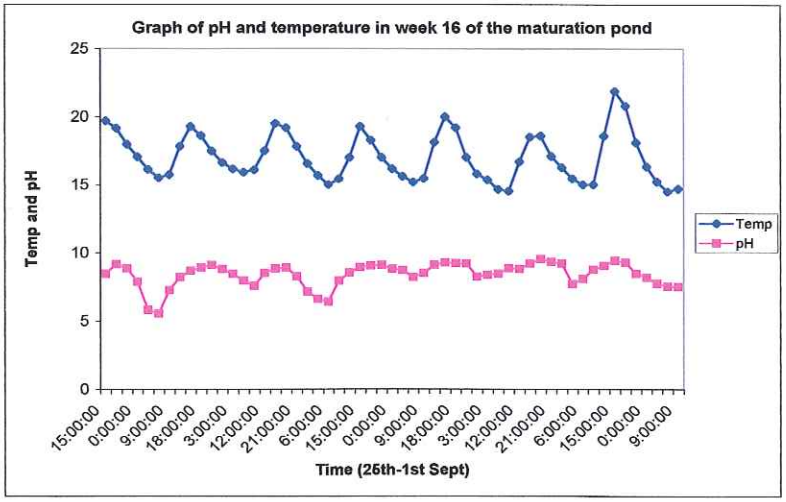

Figure A.15 Graph showing the fluctuations in pH and temperature during continuous reading in week 16

(d) 2nd – 7th September 2004 (Week 17)

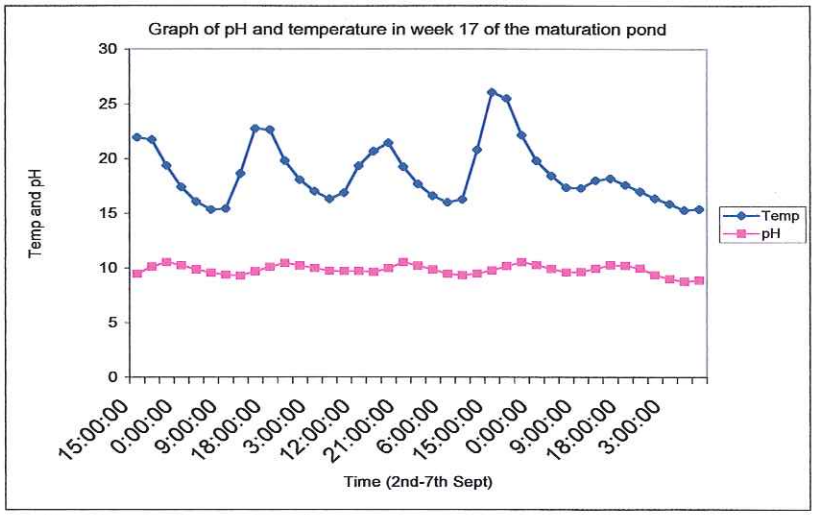

Figure A.16 Graph showing the fluctuations in pH and temperature during continuous reading in week 17

(e) 8th – 14th September 2004 (Week 18)

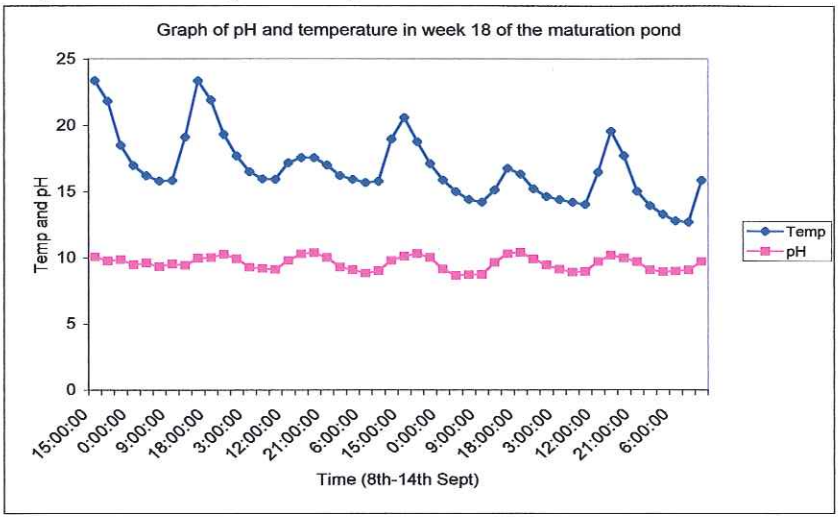

Figure A.17 Graph showing the fluctuations in pH and temperature during continuous reading in week 18

(e) 15th-21st September 2004 (Week 19)

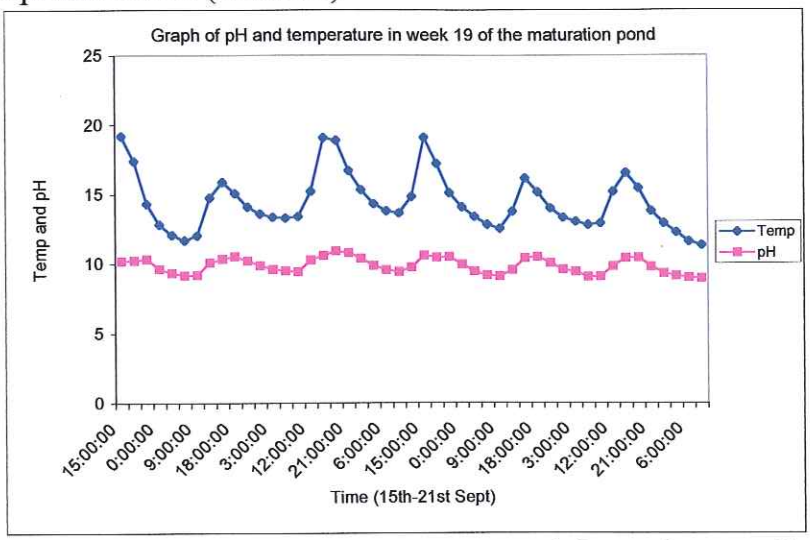

Figure A.18 Graph showing the fluctuations in pH and temperature during continuous reading in week 19

(f) 22nd – 28th September 2004 (Week 20)

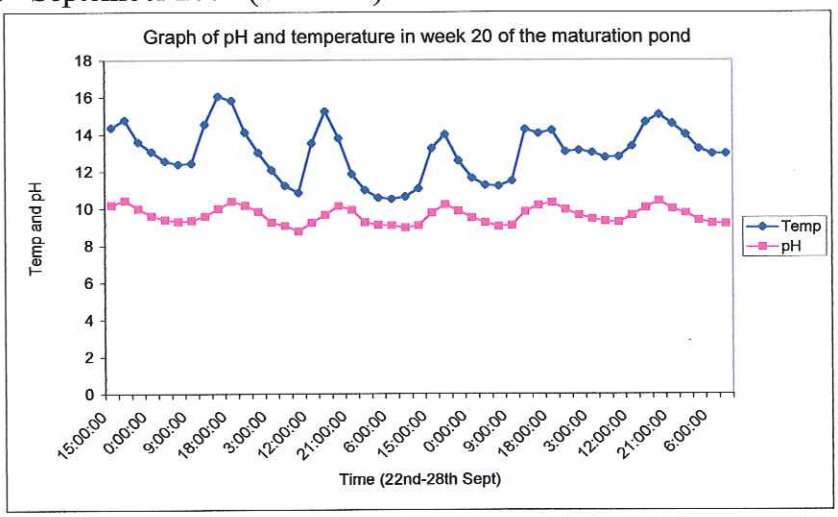

Figure A.19 Graph showing the fluctuations in pH and temperature during continuous reading in week 20

(h) 28th – 5th October 2004 (Week 21)

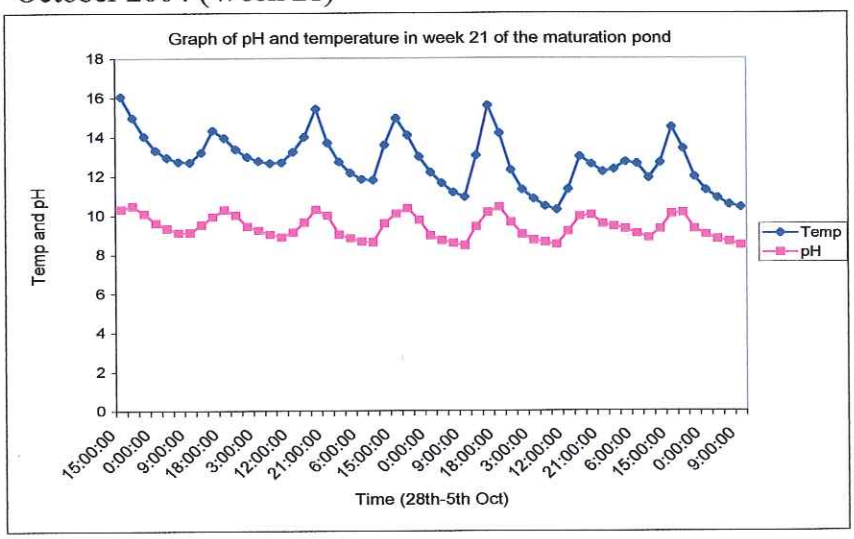

Figure A.20 Graph showing the fluctuations in pH and temperature during continuous reading in week 21

A.4 Nitrate and Nitrite results

When considering the nitrate and nitrite results, the percentage of DO was taken into consideration as a key factor when considering the possibility of nitrification and denitrification. In Tables 7.43 and 7.44 the average %DO is recorded during the different weeks of the investigation in both ponds.

A.4.1 Percentage DO content for comparison

Table A.43 Average dissolved oxygen content at the surface of the facultative pond

	Ave DO%
Week 2	16.43
Week 3	25.99
Week 4	168.85
Week 5	50.52
Week 6	90.52
Week 7&8	168.97
Week 9	124.12
Week 10	168.51
Week 11	121.07
Week 12	9.04
Week 13	12.72

Table A.44 Average dissolved oxygen content at the surface of the maturation pond

	Ave DO%
Week 14	122.53
Week 15	76.35
Week 16	170.91
Week 17	211.94
Week 18	195.48
Week 19	199.87
Week 20	181.68
Week 21	153.84

A.5 TKN results

The following tables show the results used to assess the TKN results. The tables show the volume of samples used, the amount of sulphuric acid used to change the colour of the indicator in each sample compared to a blank, and the amount of TKN calculated in mg/l.

A.5.1 Example calculation for TKN

$$NH_3\text{-N (mg/l)} = \frac{[(A - B) \_ 280]}{\text{volume of sample, ml}}$$

Where:

A = volume of acid titrated for sample (ml)

B = volume of acid titrated for blank (ml)

For example, week 4 facultative pond, sample flask 1.

NH_3-N (mg/l) = [(A – B) _ 280] / [volume of sample, ml]

NH_3-N (mg/l) = [(1.6 – 0.8) _ 280] / 50

NH_3-N (mg/l) = 4.5 mg/l

A.5.2 Facultative pond

NB: Taken on alternative weeks from week 4

(a) 12th – 19th May 2004 (Week 4)

Table A.45 Amount of total kjeldahl nitrogen found in week 4 of the facultative pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	1.6	0.8	4.5
2	50	1	0.8	1.1
3	50	1	0.8	1.1
Influent	50	5.1	0.8	24.1
Effluent	50	1.9	0.8	6.2

(b) 27th May – 2nd June 2004 (Week 6)

Table A.46 Amount of total kjeldahl nitrogen found in week 6 of the facultative pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	1.6	1	3.4
2	50	1.1	1	0.6
3	50	1	1	0
Influent	50	5.6	1	25.8
Effluent	50	2.4	1	7.8

(c) 3rd – 16th June 2004 (Week 7&8)

Table A.47 Amount of total kjeldahl nitrogen found in week7&8 of the facultative pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	2.3	0.9	7.8
2	50	1.2	0.9	1.7
3	50	0.9	0.9	0
Influent	50	10.6	0.9	54.3
Effluent	50	2.1	0.9	6.7

(d) 24th – 30th June 2004 (Week 10)

Table A.48 Amount of total kjeldahl nitrogen found in week 10 of the facultative pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	1.9	1.1	4.5
2	50	0.8	1.1	0
3	50	0.8	1.1	0
Influent	50	18.1	1.1	95.2
Effluent	50	2.9	1.1	10.1

(e) 28th July -3rd August 2004 (Week 12)

Table A.49 Amount of total kjeldahl nitrogen found in week 12 of the facultative pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	2.2	1.1	6.2
2	50	0.7	1.1	0
3	50	0.9	1.1	0
Influent	50	6	1.1	27.4
Effluent	50	2.8	1.1	9.5

(f) 4th – 11th August 2004 (Week 13)

Table A.50 Amount of total kjeldahl nitrogen found in week 13 of the facultative pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	1.5	0.9	3.4
2	50	0.6	0.9	0
3	50	0.5	0.9	0
Influent	50	4.2	0.9	18.5
Effluent	50	2.6	0.9	10.1

A.5.3 Maturation pond

NB: These were done every week due to the shorter testing period

(a) 13th – 18th August 2004 (Week 14)

Table A.51 Amount of total kjeldahl nitrogen found in week14 of the maturation pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	1	0.7	1.7
2	50	0.7	0.7	0.0
3	50	0.6	0.7	0.0
Influent	50	2	0.7	7.3
Effluent	50	1.5	0.7	4.5

(b) 19th – 24th August 2004 (Week 15)

Table A.52 Amount of total kjeldahl nitrogen found in week15 of the maturation pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	1.4	1	2.2
2	50	1	1	0
3	50	0.9	1	0
Influent	50	1.8	1	4.5
Effluent	50	1.5	1	2.8

(c) 25th August – 1st September 2004 (Week 16)

Table A.53 Amount of total kjeldahl nitrogen found in week16 of the maturation pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	1.1	0.6	2.8
2	50	0.9	0.6	1.7
3	50	0.6	0.6	0
Influent	50	1.7	0.6	6.2
Effluent	50	1.2	0.6	3.4

(c) 2nd – 7th September 2004 (Week 17)

Table A.54 Amount of total kjeldahl nitrogen found in week17 of the maturation pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	0.9	0.6	1.7
2	50	0.6	0.6	0
3	50	0.6	0.6	0
Influent	50	2.1	0.6	8.4
Effluent	50	1.6	0.6	5.6

(d) 8th – 14th September 2004 (Week 18)

Table A.55 Amount of total kjeldahl nitrogen found in week18 of the maturation pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	1.1	0.5	3.4
2	50	0.6	0.5	0.6
3	50	0.5	0.5	0
Influent	50	2.4	0.5	10.6
Effluent	50	1.8	0.5	7.3

(e) 15th – 21st September 2004 (Week 19)

Table A.56 Amount of total kjeldahl nitrogen found in week19 of the maturation pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	1	0.7	1.7
2	50	0.4	0.7	0
3	50	0.5	0.7	0
Influent	50	2.5	0.7	10.1
Effluent	50	2.1	0.7	7.8

(f) 22nd – 28th September 2004 (Week 20)

Table A.57 Amount of total kjeldahl nitrogen found in week20 of the maturation pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	0.9	0.6	1.7
2	50	0.6	0.6	0.0
3	50	0.6	0.6	0.0
Influent	50	2.2	0.6	9.0
Effluent	50	1.8	0.6	6.7

(g) 28th – 5th October 2004 (Week 21)

Table A.58 Amount of total kjeldahl nitrogen found in week21 of the maturation pond

Sample I.D.	Vol used	Titre	Blank Titre	TKN (mg/l)
1	50	0.7	0.4	1.7
2	50	0.5	0.4	0.6
3	50	0.4	0.4	0.0
Influent	50	2.5	0.4	11.8
Effluent	50	2	0.4	9.0

A.6 Total Nitrogen Calculations

A.6.1 Example Calculation for Total Nitrogen

The total nitrogen load removed per day was calculated using the following equation:

$$\text{Total Nitrogen Load removed/day (g/day)} = \frac{[(TKN_i + Na_i + Ni_i) \_ I] - [(TKN_o + Na_o + Ni_o) \_ O)]}{\text{No\# days}}$$

Where:

TKN_i = Total Kjeldahl Nitrogen in (mg/l)

TKN_o = Total Kjeldahl Nitrogen out (mg/l)

Na_i = Nitrate-N in (mg/l)

Na_o = Nitate-N out (mg/l)

Ni_i = Nitrite-N in (mg/l)

Ni_o = Nitrite-N out (mg/l)

I = Inflow (m^3/day)

O = Outflow (m^3/day)

For example week 4 of the facultative pond.

$$\text{Total N Load removed/day} = \frac{[(24.1 + 0 + 0) \_ 0.943] - [(6.2 + 0.068 + 0) \_ 2.412)]}{5}$$

$$\text{Total N Load removed/day} = \frac{22.7263 - 6.268}{5}$$

Total N Load removed/day = 1.52g/day

A.6.2 Facultative pond

Table A.59 Calculations of total nitrogen removal in the facultative pond

	TKN in mg/l	Nitrate -N in mg/l	Nitrite-N in mg/l	Total Nitrogen in mg/l	In flow m3/day	Total Nitrogen load in g/day	TKN out mg/l	Nitrate -N out mg/l	Nitrite-N out mg/l	Total Nitrogen out mg/l	Out flow m3/day	Total Nitrogen load out g/day	Total N load removed g/day	No# days	Total N load removed / day g/day
Week 4	24.1	0	0	24.1	0.943	22.7263	6.2	0.068	0	6.268	2.412	15.11842	7.607884	5	1.5215
Week 6	25.8	0	0	25.8	0.943	24.3294	7.8	0	0	7.8	2.412	18.8136	5.5158	6	0.9193
Week 7&8	54.3	0	0	54.3	0.835	45.3405	6.7	0	0	6.7	2.794	18.7198	26.6207	13	2.0477
Week 10	95.2	0	0	95.2	0.835	79.492	10.1	0	0	10.1	2.794	28.2194	51.2726	6	8.5454
Week 12	27.4	0.06	0	27.461	0.835	22.92994	9.5	0.027	0	9.527	2.794	26.61844	3.688503	6	0.6147

A.6.3 Maturation pond

Table A.60 Calculations of total nitrogen removal in the maturation pond

	TKN in mg/l	Nitrate-N in mg/l	Nitrite-N in mg/l	Total Nitrogen in mg/l	Inflow m3/day	Total Nitrogen load in g/day	TKN out mg/l	Nitrate -N out mg/l	Nitrite-N out mg/l	Total Nitrogen out mg/l	Out flow m3/day	Total Nitrogen load out g/day	Total N load removed g/day	No# days	Total N load removed / day g/day
Week 14	7.3	0	0	7.3	0.612	4.4676	4.5	0	0	4.5	0.612	2.754	1.7136	5	0.3427
Week 15	4.5	0	0	4.5	0.612	2.754	2.8	0	0	2.8	0.612	1.7136	1.0404	5	0.2081
Week 16	6.2	0.088	0	6.288	0.612	3.8483	3.4	0.038	0	3.4	0.612	2.0808	1.7675	7	0.2525
Week 17	8.4	0.056	0	8.456	0.612	5.1751	5.6	0.02	0	5.6	0.612	3.4272	1.7479	5	0.3496
Week 18	10.6	0.149	0.265	10.749	0.612	6.5784	7.3	0.02	0	7.3	0.612	4.4676	2.1108	6	0.3518

A.7 Ammonia Stripping Model Calculations

A.7.1 Example calculation for the ammonia stripping model

The ammonia stripping model follows this equation:

$$C_e = \frac{C_i}{\{1 + [(A/Q)(0.0038 + 0.000134^{T}) \_ \exp((1.041 + 0.044^{T})(pH - 6.6))]\}}$$

Where:

C_e = NH_3-N concentration for effluent (mg/l)

C_i = NH_3-N concentration for influent (mg/l)

A = Pond surface area (m^2)

Q = Flow (m^3/day)

T = Temperature (°C)

Therefore during week 2 of the facultative pond (15^{th} – 20^{th} April) the data was as follows:

C_i = 12.82mg/l

NB. For the facultative pond the original influent concentration in the results had to be diluted to include the tap water constituent as well as the sewage. This was done by multiplying the sewage influent concentration by, the sewage flow divided by the total flow. So in this example 39.8 _ (0.82 / 2.545) = 12.82. In the maturation pond, the dilution was already included in the influent concentration so they remained the same.

A = 33.6m^2

Q = 0.54m^3/day

T = 10.95°C

$$C_e = \frac{12.82}{\{1 + [(33.6/0.54)(0.0038 + 0.000134^{10.95}) \_ \exp((1.041 + 0.044^{10.95})(6.22 - 6.6))]\}}$$

$$C_e = \frac{12.82}{\{1 + [(62.2)(0.0038) \_ \exp((1.041)(-0.38))]\}}$$

$$C_e = \frac{12.82}{\{1 + [(0.2364) \_ \exp(-0.39558)]\}}$$

$$C_e = \frac{12.82}{\{1 + [0.2364 \_ 0.67329]\}}$$

$$C_e = \frac{12.82}{1.159195542}$$

C_e = 11.062mg/l

A.7.2 Facultative pond

Table A.61 Calculation stages using the ammonia stripping model for the facultative pond

	Influent	Infl after dilution	S. area (A)	Flow (Q)	pH	Temp	A/Q	0.0038+ 0.000134^T	pH section	1.041+ 0.044^T	Exp section	A/Q * I	Exp of column L	Bottom sect of eq.	Total
Week 2	39.8	12.82358	33.6	0.54	6.22	10.95	62.222	0.0038	-0.38	1.041	-0.3956	0.2364	0.67329	1.159196	11.0625
Week 3	24.5	7.89391	33.6	0.54	6.63	13.46	62.222	0.0038	0.03	1.041	0.0312	0.2364	1.03172	1.243945	6.3459
Week 4	18.6	5.99293	33.6	0.943	8.3	18.25	35.631	0.0038	1.7	1.041	1.7697	0.1354	5.86909	1.794661	3.3393
Week 5	50.1	16.14224	33.6	0.943	7.01	16.9	35.631	0.0038	0.41	1.041	0.4268	0.1354	1.53236	1.207478	13.3686
Week 6	24	7.73281	33.6	0.943	7.49	17.2	35.631	0.0038	0.89	1.041	0.9265	0.1354	2.52563	1.341964	5.7623
Week 7&8	39.8	12.82358	33.6	0.835	8.78	20.44	40.239	0.0038	2.18	1.041	2.2694	0.1529	9.67340	2.479162	5.1725
Week 9	11.2	3.60864	33.6	0.835	7.84	17.11	40.239	0.0038	1.24	1.041	1.2908	0.1529	3.63584	1.555957	2.3192
Week 10	49	15.78782	33.6	0.835	8.74	17.85	40.239	0.0038	2.14	1.041	2.2277	0.1529	9.27887	2.418834	6.5270
Week 11	49	15.78782	33.6	0.835	8.72	18.6	40.239	0.0038	2.12	1.041	2.2069	0.1529	9.08768	2.389599	6.6069
Week 12	19.5	6.28291	33.6	0.835	6.91	21.41	40.239	0.0038	0.31	1.041	0.3227	0.1529	1.38086	1.211148	5.1876
Week 13	18.2	5.86405	33.6	0.835	7.04	22.12	40.239	0.0038	0.44	1.041	0.4580	0.1529	1.58097	1.241747	4.7224

A.7.3 Maturation pond

Table A.62 Calculation stages using the ammonia stripping model for the maturation pond

	Influent	S. area (A)	Flow (Q)	pH	Temp	A/Q	0.0038+ 0.000134^T	pH section	1.041+ 0.044^T	Exp section	A/Q * G	Exp of column J	Bottom sect of eq.	Total
Week 14	1.45	18.3	0.612	8.82	20.98	29.886	0.0038	2.22	1.041	2.311	0.113565	10.0847	2.14527	0.6759
Week 15	4.47	18.3	0.612	7.06	17.44	29.886	0.0038	0.46	1.041	0.4789	0.113565	1.6142	1.18332	3.7775
Week 16	4.07	18.3	0.612	8.42	17.59	29.886	0.0038	1.82	1.041	1.8946	0.113565	6.6500	1.75521	2.3188
Week 17	8.71	18.3	0.612	9.81	18.65	29.886	0.0038	3.21	1.041	3.3416	0.113565	28.2646	4.20988	2.0689
Week 18	8.71	18.3	0.612	9.55	16.72	29.886	0.0038	2.95	1.041	3.071	0.113565	21.5624	3.44874	2.5256
Week 19	6.76	18.3	0.612	9.87	14.47	29.886	0.0038	3.27	1.041	3.4041	0.113565	30.0863	4.41676	1.5305
Week 20	5.37	18.3	0.612	9.62	13.03	29.886	0.0038	3.02	1.041	3.1438	0.113565	23.1923	3.63384	1.4778
Week 21	5.37	18.3	0.612	9.37	13.4	29.886	0.0038	2.77	1.041	2.8836	0.113565	17.8780	3.03032	1.7721