CHAPTER 4

RESULTS

4.0 RESULTS

4.1 Field physical and chemical parameters

The details of physical and chemical parameters for each station between December to March 2001 are as shown in Appendix 1. These parameters include temperature, pH, conductivity, dissolved oxygen, secchi depth, dissolved orthophosphate, ammoniacal nitrogen and silica. One-way ANOVA to detect the differences between station means of each parameter and Tukey honest significant different test was used.

4.1.1 Temperature

Figure 8 depicts the surface water for the five sampling stations ranging from 27.6°C to 32.0°C. The highest temperature was recorded at station III (10th March 2001) and the lowest temperature was recorded at station II (23rd December 2000). The temperature of waters in March 2002 were higher compared to other months. Figure 9 shows the mean temperature of each station from December 2000 to March 2001 which were not significantly different from each other.

4.1.2 pH

Figure 10 shows all the water samples have slightly acidic pH except in December 2000 where some of the water samples recorded alkaline pH. The lowest and highest pHs were 6.00 and 7.90 on 24th February 2001 and 6th December 2000 respectively at station IV. Figure 11 shows the mean pH of the five stations ranging from 6.57 to 6.70, which were not significantly different from each other.

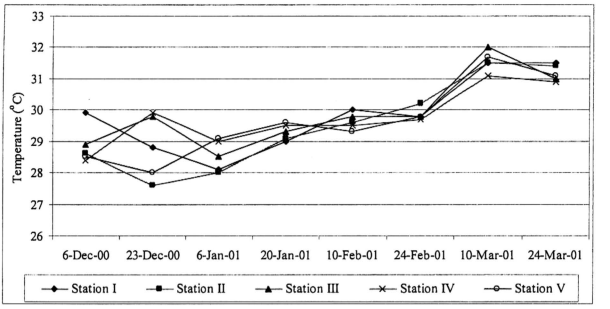

Figure 8. Temperature for each station

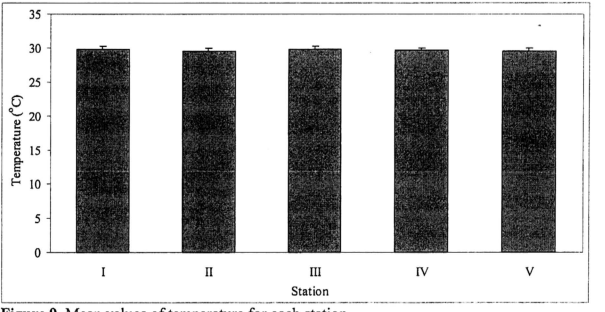

Figure 9. Mean values of temperature for each station
Error bars denote standard error.

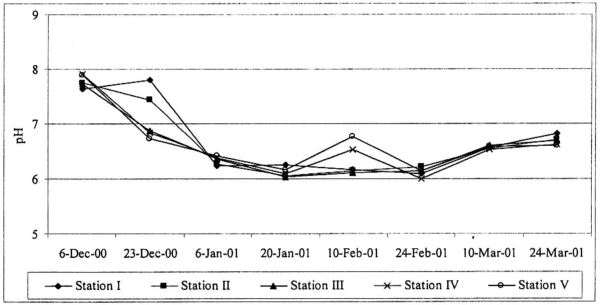

Figure 10. pH for each station

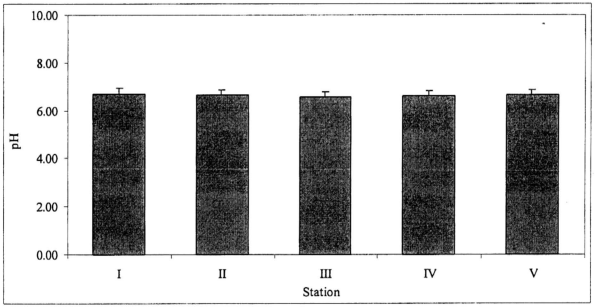

Figure 11. Mean values of pH for each station
Error bars denote standard error.

4.1.3 Conductivity

Figure 12 presents the trends of conductivity of each station. The highest conductivity level was 110.9 $\mu S\ cm^{-1}$ at station I on 24th March 2001 while the lowest was 68.5 $\mu S\ cm^{-1}$ at station V on 20th January 2001. Generally station I has the highest conduction level at each sampling occasion except in February 2001. Figure 13 shows the mean conductivity for each station ranging from 83.8 $\mu S\ cm^{-1}$ to 94.3 $\mu S\ cm^{-1}$. However, these were not significantly different from each other.

4.1.4 Dissolved oxygen

Figure 14 presents the trends of dissolved oxygen (DO) either equal or greater than 5 mg L^{-1}. The differences between the DO values for each sampling occasion were less than one unit except on 24th February 2001. Figure 15 shows the mean dissolved oxygen ranging from 6.0 mg L^{-1} to 6.4 mg L^{-1}. These were not significantly different from each other.

4.1.5 Secchi depth

Figure 16 presents the trends of secchi depth for stations I, II and V only because the waters at stations III and IV were shallow (0.3 - 0.5 m) and the base of both sampling stations were visible. The highest and lowest secchi depth recorded were 1.2 m and 0.1 m at station I and station II on 24th March 2001 and 24th February 2001 respectively. Figure 17 shows mean secchi depth ranging between 0.35 m and 0.76 m for stations I, II and V. Station II had the lowest secchi depth and was significantly different from station V ($p < 0.05$) but not station I.

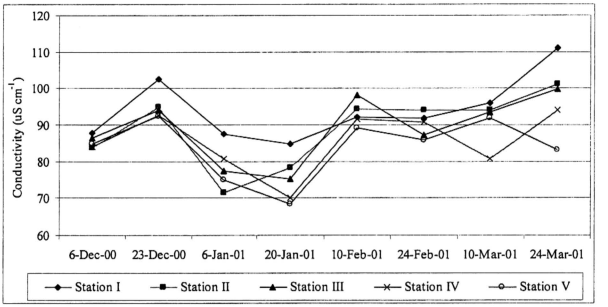

Figure 12. Conductivity for each station

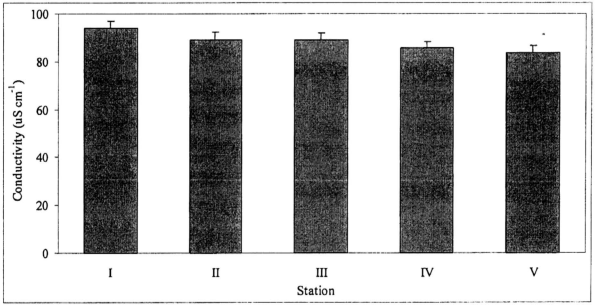

Figure 13. Mean values of conductivity for each station.
Error bars denote standard error.

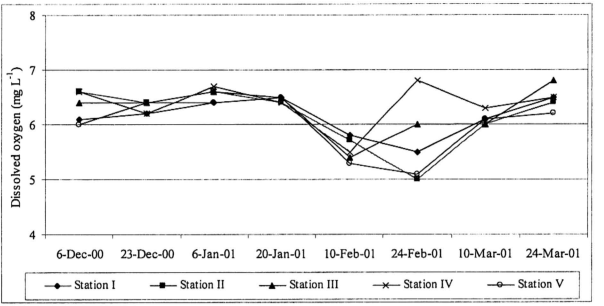

Figure 14. Dissolved oxygen for each station

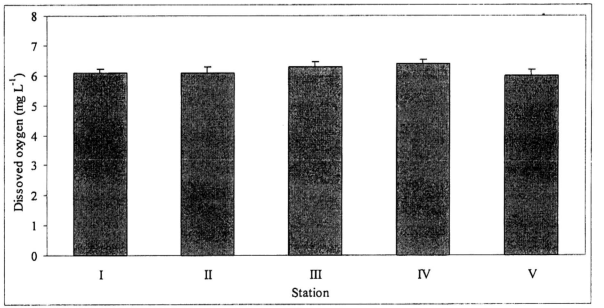

Figure 15. Mean values of dissolved oxygen for each station.
Error bars denote standard error.

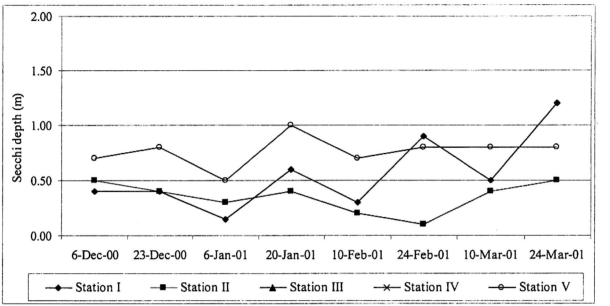

Figure 16. Secchi depth for each station

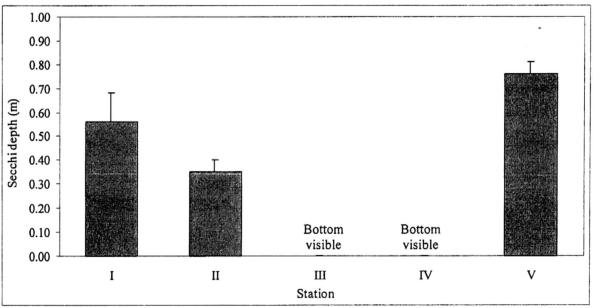

Figure 17. Mean values of secchi depth for each station.
Error bars denote standard error.

4.1.6 Dissolved orthophosphate

Figure 18 shows that there were different trends of dissolved orthophosphate at each station. The highest concentration of dissolved orthophosphate was 0.0077 mg L^{-1} at station V on 6th December 2000 while the lowest concentration was 0.0004 mg L^{-1} at station IV on 24th March 2001. Figure 19 shows the mean dissolved orthophosphate ranging from 0.0016 mg L^{-1} to 0.0028 mg L^{-1}. Station II had the highest, and station III had the lowest, concentration but not significantly different from each other.

4.1.7 Ammoniacal nitrogen

Figure 20 gives the trends of ammoniacal nitrogen at each station which were fluctuated and did not showed a similar trend. Station V had the highest concentration (0.0923 mg L^{-1}) on 6th December 2000 while station III had the lowest concentration (0.0015 mg L^{-1}) on 23rd December 2000. Figure 21 shows the mean ammoniacal nitrogen ranging from 0.0161 mg L^{-1} to 0.0408 mg L^{-1}. The concentrations were not significantly different from each station. Station III had the highest, and station IV had the lowest, concentration but were not significantly different from each other.

The concentrations of ammoniacal nitrogen and dissolved orthophosphate had different patterns. Station III had the lowest dissolved orthophosphate but the highest ammoniacal nitrogen concentration.

4.1.8 Silica

Figure 22 shows the trends of silica at each station. Station II had the highest concentration (9.28 mg L^{-1}) on 24th February 2001 and lowest concentration (3.18 mg L^{-1}) on 6th January 2001. Figure 23 shows the mean silica ranging from 3.77 to 5.97 mg L^{-1}. Stations I and II had significantly higher levels than stations III, IV and V ($p < 0.05$).

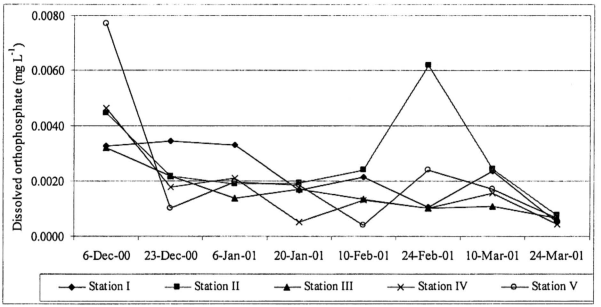

Figure 18. Dissolved orthophosphate for each station

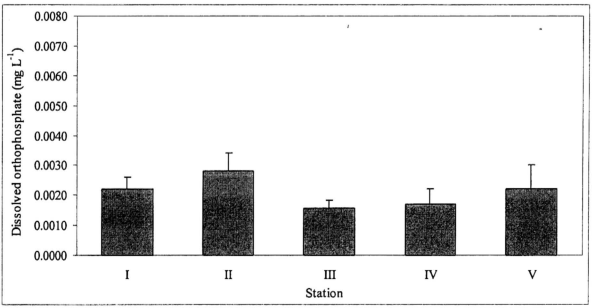

Figure 19. Mean values of dissolved orthophosphate for each station. Error bars denote standard error.

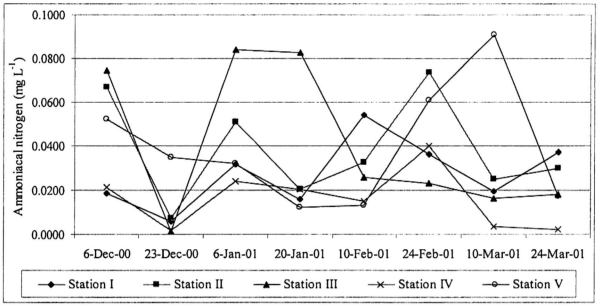

Figure 20. Ammoniacal nitrogen for each station

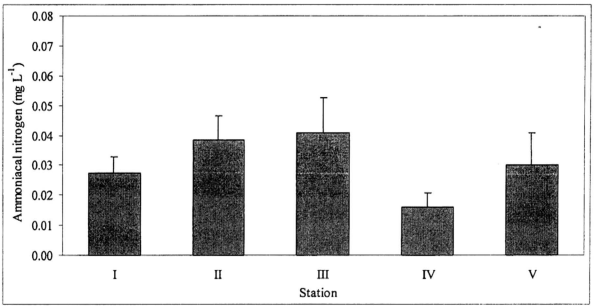

Figure 21. Mean values of ammoniacal nitrogen for each station. Error bars denote standard error.

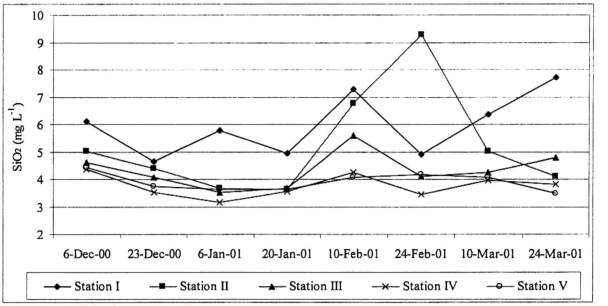

Figure 22. SiO_2 for each station

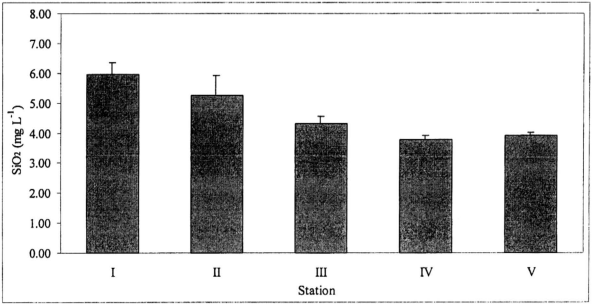

Figure 23. Mean values of SiO_2 for each station.
Error bars denote standard error.

4.2 Biotic variables

The details of biotic variables (chlorophyll-a, cell density, species richness and Shannon-Wiener's diversity index) at each station are as shown in Appendix 2.

4.2.1 Checklist of phytoplankton and abundance

A total of 27 species were found at the five sampling stations from December 2000 to April 2001. 15 species of Chlorophyta, 11 species of Chrysophyta and one species of Pyrrhophyta were recorded as tabulated in Table 3. The abundance of diatoms was rather low compared with other algae.

The common species found in the five stations were *Trachelomonas* sp. (Figure 24), *Uronema confervicolum* (Figure 25), *Scenedesmus bijuga* (Figure 26), *Ankistrodesmus falcatus* (Figure 27), *Ceratium hirundinella* (Figure 28) and *Dinobryon sertularia* (Figure 29).

4.2.2 Cell density

Table 4 tabulates cell density of each sampling occasion at each station which ranged from 20 cells L^{-1} for *Gleocapsa* sp. at station III on 24th March 2001, *Cosmarium medioscrobiculatum*, *Lepocinclis spirogyra* and *Staurastrum diptilum* at station V on 10th March 2001 to 86400 cells L^{-1} for *Trachelomonas* sp. at the same station on 20th January 2001.

Figure 30 shows the lowest cell density recorded for the eight sampling occasions was 4490 cells L^{-1} on 6 January 2001 at station I and the highest cell density was 142020 cells L^{-1} on 20th January 2001 at station III.

Table 3. List of phytoplankton at station I to V

		Station					Frequency (%)
		I	II	III	IV	V	
Division :	Chlorophyta						
Class :	Chlorophyceae						
Order :	Chlorococcales						
Family :	Oocystaceae						
	Ankistrodesmus falcatus (Corda) Ralfs	x	x	x	x	x	100
Family :	Coelastraceae						
	Coelastrum reticulatum (Dangeard) Senn	x	x	x	x	x	100
Family :	*Scenedesmaceae*						
	Scenedesmus bijuga (Turpin) Lagerheim	x	x	x	x	x	100
	Scenedesmus quadricada (Turpin) Brebisson		x	x		x	60
Family :	Micractiniaceae						
	Golenkinia radiata Chodat	x			x		40
Order :	Ulotrichales						
Family :	Ulotrichaceae						
	Uronema confervicolum Lagerheim	x	x	x	x	x	100
Order :	Zygnematales						
Family :	Desmidiaceae						
	Staurastrum tetracerum Ralfs	x	x	x	x	x	100
	Cosmarium mediosc robiculatum West & G.S. West		x	x	x	x	80
	Staurastrum diptilum Nordstedt		x	x	x	x	80
	Staurastrum pentacerum (Wolle) G. M. Smith		x	x	x	x	80
	Spondylosium pygaeum Rabenhorst			x		x	40
	Staurastrum leptocladum Nordstedt			x		x	40
	Staurastrum sp.			x	x		40
	Closterium setaceum Ehrenberg		x				20
	Closterium tumidum Johnson		x				20
Division :	Chrysophyta						
Class :	Chrysophyceae						
Order :	Ochromonadales						
Family :	Dinobryonaceae						
	Dinobryon sertularia Ehrenberg	x	x	x	x	x	100
Class :	Bacillariophyta						
Order :	Naviculales						
Family :	Naviculaceae						
	Navicula bacillum Ehrenberg	x	x	x	x	x	100
	Navicula sp. Bory	x	x	x	x	x	100
	Frustulia sp. Rabenhorst				x		20

Table 3. List of phytoplankton at station I to V (continued)

		Station					Frequency
		I	II	III	IV	V	
Family :	Cymbellaceae						
	Cymbella sp. Agardh	x	x	x	x	x	100
Order :	Ochromonales						
Family :	Synuraceae						
	Mallomonas splendens (G. S. West) Playfair	x	x	x	x	x	100
Division :	Cyanophyta						
Class :	Cyanophyceae						
Order :	Chroococcales						
Family :	Chroococcaceae						
	Merismopedia sp. Meyen	x	x	x	x	x	100
	Gloecapsa sp. Kutzing		x	x	x	x	80
Order :	Oscillatoriales						
Family :	Oscillatoriaceae						
	Oscillatoria tenuis Agardh	x	x	x	x	x	100
Division :	Euglenophyta						
Class :	Euglenophyceae						
Order :	Euglenales						
Family :	Euglenaceae						
	Lepocinclis spirogyra Korschikoff	x	x	x	x	x	100
	Trachelomonas sp. Ehrenberg	x	x	x	x	x	100
Division :	Pyrrophyta						
Class :	Dinophyceae						
Order :	Peridiniales						
Family :	Ceratiaceae						
	Ceratium hirundinella (O.F.M.) Schrank	x	x	x	x	x	100
Total no. of taxa		16	22	23	22	22	

Note: x - present at the station

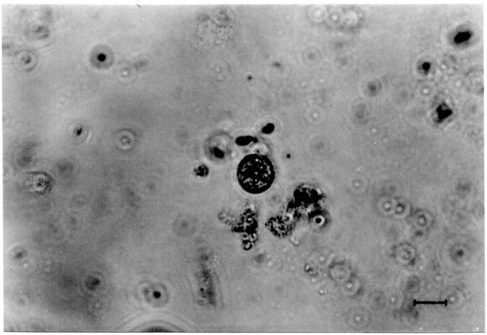

Figure 24. *Trachelomonas* sp. (scale bar = 10 μm)

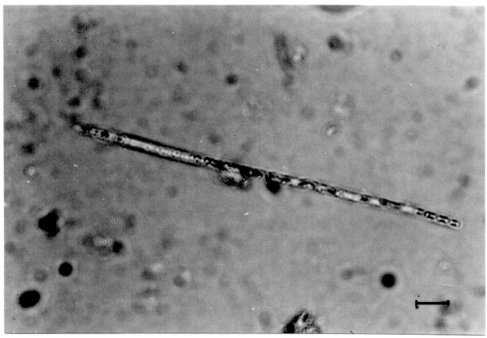

Figure 25. *Uronema confervicolum* (scale bar = 10 μm)

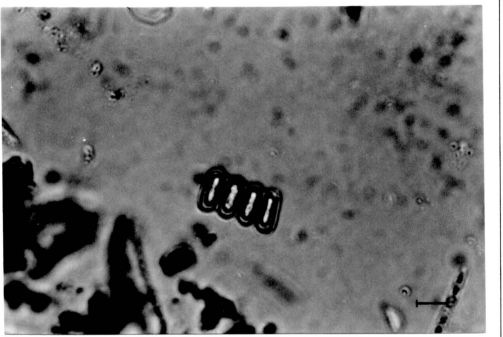

Figure 26. *Scenedesmus bijuga* (scale bar = 10 μm)

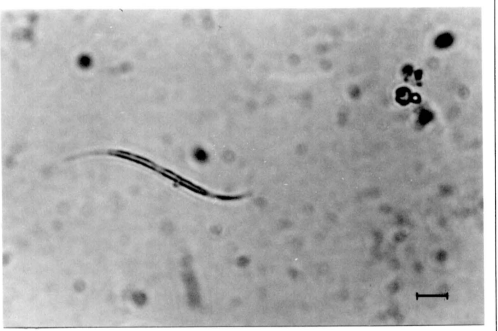

Figure 27. *Ankistrodesmus falcatus* (scale bar = 10 μm)

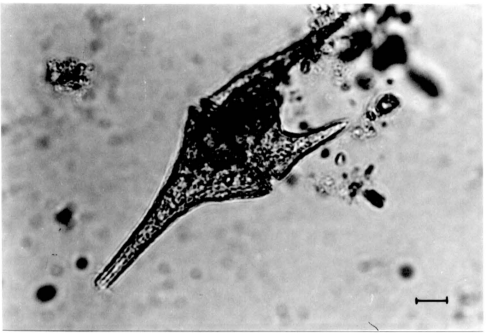

Figure 28. *Ceratium hirundinella* (scale bar = 10 μm)

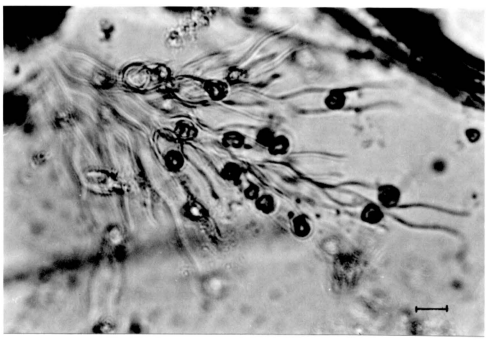

Figure 29. *Dinobryon sertularia* (scale bar = 10 μm)

Table 4. Phytoplankton abundance (cells L^{-1}) at station I

	Occasion								
	1	2	3	4	5	6	7	8	Frequency (%)
Dinobryon sertularia Ehrenberg	27800	630	270	11400	660	2160	650	1400	100
Navicula sp. Bory	240	180	270	120	1210	820	150	600	100
Oscillatoria tenuis Agardh	160	90	40	300	660	390	700	1300	100
Trachelomonas sp. Ehenberg	1280	5580	2430	7740	7480	9840	5000	600	100
Ankistrodesmus falcatus (Corda) Ralfs	0	360	130	300	770	1650	2500	900	87.5
Ceratium hirundinella (O.F.M) Schrank	80	450	540	480	1870	520	600	0	87.5
Navicula bacillum Ehrenberg	320	720	630	1200	880	2380	450	0	87.5
Cymbella sp. Agardh	0	0	0	0	0	0	300	50	25
Coelastrum reticulatum (Dangeard) Senn	80	0	0	0	0	90	0	0	25
Lepocinclis spirogyra Korschikoff	0	0	0	180	0	0	100	0	25
Staurastrum tetracerum Ralfs	240	0	0	0	0	0	0	30	25
Uronema confervicolum Lagerheim	560	630	0	0	0	0	0	0	25
Golenkinia radiata Chodat	0	180	0	0	0	0	0	0	12.5
Mallomonas splendens (G. S. West) Playfair	0	0	180	0	0	0	0	0	12.5
Merismopedia sp. Meyen	0	0	0	0	0	0	100	0	12.5
Scenedesmus bijuga (Turpin) Lagerheim	0	0	0	0	0	40	0	0	12.5
TOTAL	30760	8820	4490	21720	13530	17890	10550	4880	

Note: Occasion 1 = 6th Dec 2000; Occasion 2 = 23rd Dec 2000; Occasion 3 = 6th Jan 2001; Occasion 4 = 20th Jan 2001; Occasion 5 = 10th Feb 2001; Occasion 6 = 24th Feb 2001; Occasion 7 = 10th Mar 2001; Occasion 8 = 24th Mar 2001

Table 5. Phytoplankton abundance (cells L^{-1}) at station II

	Occasion								
	1	2	3	4	5	6	7	8	Frequency (%)
Ankistrodesmus falcatus (Corda) Ralfs	526	850	280	363	1800	1200	4530	3981	100
Navicula bacillum Ehenberg	1170	960	7070	2050	6030	2800	4750	7400	100
Navicula sp. Bory	320	750	470	950	1620	4050	1060	1300	100
Staurastrum tetracerum Ralfs	1170	746	560	1246	1260	300	320	89	100
Trachelomonas sp. Ehenberg	37000	19600	41100	86400	11430	24000	7140	1200	100
Staurastrum tetracerum Ralfs	1170	746	560	1246	1260	300	320	89	100
Trachelomonas sp. Ehenberg	37000	19600	41100	86400	11430	24000	7140	1200	100
Dinobryon sertularia Ehrenberg	2670	0	350	290	4320	1100	320	200	87.5
Oscillatoria tenuis Agardh	320	0	70	360	270	1150	1010	1000	87.5
Uronema confervicolum Lagerheim	42000	13500	12200	28900	6660	24400	9010	0	87.5
Ceratium hirundinella (O.F.M) Schrank	2030	3950	420	290	4770	950	0	0	75
Scenedesmus bijuga (Turpin) Lagerheim	106	0	280	366	0	150	0	0	50
Staurastrum diptilum Nordstedt	3410	0	280	3080	90	0	0	0	50
Lepocinclis spirogyra Korschikoff	110	106	0	0	90	0	0	0	37.5
Mallomonas splendens (G. S. West) Playfair	420	106	0	0	270	0	0	0	37.5
Closterium setaceum Ehrenberg	0	0	0	0	90	0	260	0	25
Cymbella sp. Agardh	0	0	0	0	0	0	480	98	25
Merismopedia sp. Meyen	210	0	0	0	0	0	106	0	25
Gloecapsa sp. Kutzing	0	0	70	0	270	0	0	0	25
Closterium tumidum Johnson	0	0	0	0	90	0	0	0	12.5
Coelastrum reticulatum (Dangeard) Senn	0	0	0	0	180	0	0	0	12.5
Cosmarium mediocrobiculatum West & G.S. West	0	0	0	220	0	0	0	0	12.5
Scenedesmus quadricada (Turpin) Brebisson	106	0	0	0	0	0	0	0	12.5
Staurastrum pentacerum (Wolle) G.M. Smith	210	0	0	0	0	0	0	0	12.5
TOTAL	91778	40568	63150	124515	39240	60100	28986	15268	

Note: Occasion 1 = 6th Dec 2000; Occasion 2 = 23rd Dec 2000; Occasion 3 = 6th Jan 2001; Occasion 4 = 20th Jan 2001; Occasion 5 = 10th Feb 2001; Occasion 6 = 24th Feb 2001; Occasion 7 = 10th Mar 2001; Occasion 8 = 24th Mar 2001

Table 6. Phytoplankton abundance (cells L^{-1}) at station III

	Occasion								
	1	2	3	4	5	6	7	8	Frequency (%)
Ankistrodesmus falcatus (Corda) Ralfs	820	920	480	650	3830	1700	5460	5510	100
Dinobryon sertularia Ehrenberg	3960	420	380	260	490	1850	370	320	100
Navicula bacillum Ehenberg	2560	2250	8120	3380	15400	2350	7090	3950	100
Navicula sp. Bory	580	1330	3860	1300	5800	1650	2380	3360	100
Oscillatoria tenuis Agardh	460	830	480	650	1730	1150	1960	1550	100
Staurastrum tetracerum Ralfs	1280	1490	380	520	1730	4550	1120	920	100
Trachelomonas sp. Ehenberg	41530	52700	46300	72500	26500	48200	13900	1540	100
Uronema confervicolum Lagerheim	14800	18600	31500	57300	16400	32400	9520	3520	100
Ceratium hirundinella (O.F.M) Schrank	3380	1670	90	1820	2840	1950	700	0	87.5
Scenedesmus bijuga (Turpin) Lagerheim	120	80	290	390	980	100	140	0	87.5
Staurastrum diptilum Nordstedt	6300	1580	2120	2860	490	100	0	0	75
Gloecapsa sp. Kutzing	0	0	90	130	490	0	0	20	50
Mallomonas splendens (G. S. West) Playfair	580	170	0	0	0	100	90	0	50
Lepocinclis spirogyra Korschikoff	0	0	0	260	120	0	50	0	37.5
Staurastrum pentacerum (Wolle) G.M. Smith	120	80	0	0	0	150	0	0	37.5
Coelastrum reticulatum (Dangeard) Senn	0	0	0	0	0	200	50	0	25
Cosmarium mediocrobiculatum West & G.S. West	0	0	0	0	120	0	50	0	25
Merismopedia sp. Meyen	0	249	0	0	0	0	50	0	25
Scenedesmus quadricada (Turpin) Brebisson	120	0	0	0	0	100	0	0	25
Cymbella sp. Agardh	0	0	0	0	0	0	0	420	12.5
Spondylosium pygaeum Rabenhorst	120	0	0	0	0	0	0	0	12.5
Staurastrum leptocladum Nordstedt	0	0	0	0	120	0	0	0	12.5
Staurastrum sp.	0	0	0	0	0	0	0	110	12.5
TOTAL	76730	82369	94090	142020	77040	96550	42930	21220	

Note: Occasion 1 = 6th Dec 2000; Occasion 2 = 23rd Dec 2000; Occasion 3 = 6th Jan 2001; Occasion 4 = 20th Jan 2001; Occasion 5 = 10th Feb 2001; Occasion 6 = 24th Feb 2001; Occasion 7 = 10th Mar 2001; Occasion 8 = 24th Mar 2001

Table 7. Phytoplankton abundance (cells L^{-1}) at station IV

	Occasion								
	1	2	3	4	5	6	7	8	Frequency (%)
Ankistrodesmus falcatus (Corda) Ralfs	530	340	470	380	6890	1390	10100	6840	100
Ceratium hirundinella (O.F.M) Schrank	1170	560	570	670	2340	1600	580	370	100
Navicula bacillum Ehenberg	1060	1300	8740	2710	13000	6560	10400	13800	100
Navicula sp. Bory	2880	1360	850	1250	6630	3150	1600	6720	100
Oscillatoria tenuis Agardh	750	340	90	380	910	1490	850	310	100
Staurastrum tetracerum Ralfs	1490	1470	1620	190	1950	7280	1330	620	100
Trachelomonas sp. Ehenberg	30600	41200	26900	52400	63600	62500	20200	10480	100
Uronema confervicolum Lagerheim	5330	26600	24600	22600	27800	35200	13600	120	100
Dinobryon sertularia Ehrenberg	2980	110	660	870	1430	2170	580	0	87.5
Staurastrum diptilum Nordstedt	4370	3390	760	1830	650	210	0	370	87.5
Scenedesmus bijuga (Turpin) Lagerheim	430	110	570	290	910	0	160	0	75
Cosmarium mediocrobiculatum West & G.S. West	110	0	0	0	130	50	0	180	50
Lepocinclis spirogyra Korschikoff	0	60	0	100	520	0	0	0	37.5
Mallomonas splendens (G. S. West) Playfair	750	680	90	0	0	0	0	0	37.5
Staurastrum pentacerum (Wolle) G.M. Smith	0	60	0	0	130	160	0	0	37.5
Coelastrum reticulatum (Dangeard) Senn	0	0	0	0	0	160	50	0	25
Gloecapsa sp. Kutzing	0	0	0	0	260	0	0	120	25
Cymbella sp. Agardh	0	0	0	0	0	0	0	920	12.5
Frustulia sp. Rabenhorst	0	0	0	0	0	0	0	60	12.5
Golenkinia radiata Chodat	0	0	0	0	130	0	0	0	12.5
Merismopedia sp. Meyen	0	60	0	0	0	0	0	0	12.5
Staurastrum sp.	0	0	0	0	0	0	0	120	12.5
TOTAL	52450	77640	65920	83670	127280	121920	59450	41030	

Note: Occasion 1 = 6th Dec 2000; Occasion 2 = 23rd Dec 2000; Occasion 3 = 6th Jan 2001; Occasion 4 = 20th Jan 2001; Occasion 5 = 10th Feb 2001; Occasion 6 = 24th Feb 2001; Occasion 7 = 10th Mar 2001; Occasion 8 = 24th Mar 2001

Table 8. Phytoplankton abundance (cells L^{-1}) at station V

	Occasion								
	1	2	3	4	5	6	7	8	Frequency (%)
Ankistrodesmus falcatus (Corda) Ralfs	1440	1330	570	120	3060	980	3430	6090	100
Ceratium hirundinella (O.F.M) Schrank	1530	490	280	1630	2380	940	690	100	100
Dinobryon sertularia Ehrenberg	3060	160	100	580	1020	7150	500	150	100
Navicula bacillum Ehenberg	2970	1920	4750	5360	7480	2610	8710	7440	100
Navicula sp. Bory	2070	1580	660	930	2830	990	590	1810	100
Oscillatoria tenuis Agardh	360	330	100	350	560	400	160	310	100
Staurastrum tetracerum Ralfs	1890	1910	280	470	1920	4320	1280	310	100
Trachelomonas sp. Ehenberg	39330	54200	16400	46100	36900	31500	8780	4590	100
Uronema confervicolum Lagerheim	24500	37800	7600	11780	10200	17000	4990	3720	100
Scenedesmus bijuga (Turpin) Lagerheim	270	250	100	120	450	270	140	0	87.5
Staurastrum diptilum Nordstedt	6480	2910	100	2200	1020	220	20	0	87.5
Scenedesmus quadricada (Turpin) Brebisson	0	80	0	120	0	40	0	50	50
Cosmarium mediosc robiculatum West & G.S. West	0	80	0	0	0	0	20	100	37.5
Gloecapsa sp. Kutzing	0	0	0	120	110	40	0	0	37.5
Mallomonas splendens (G. S. West) Playfair	360	250	100	0	0	0	0	0	37.5
Spondylosium pygaeum Rabenhorst	0	80	0	0	0	40	40	0	37.5
Coelastrum reticulatum (Dangeard) Senn	0	80	0	0	0	0	40	0	25
Lepocinclis spirogyra Korschikoff	0	80	0	0	0	0	20	0	25
Cymbella sp. Agardh	0	0	0	0	0	0	0	100	12.5
Merismopedia sp. Meyen	90	0	0	0	0	0	0	0	12.5
Staurastrum leptocladum Nordstedt	90	0	0	0	0	0	0	0	12.5
Staurastrum pentacerum (Wolle) G.M. Smith	0	0	0	0	0	0	0	50	12.5
TOTAL	84440	103530	31040	69880	67930	66500	29410	24820	

Note: Occasion 1 = 6th Dec 2000; Occasion 2 = 23rd Dec 2000; Occasion 3 = 6th Jan 2001; Occasion 4 = 20th Jan 2001; Occasion 5 = 10th Feb 2001; Occasion 6 = 24th Feb 2001; Occasion 7 = 10th Mar 2001; Occasion 8 = 24th Mar 2001

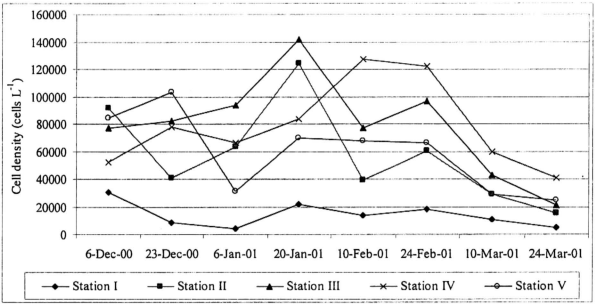

Figure 30. Cell density for each station

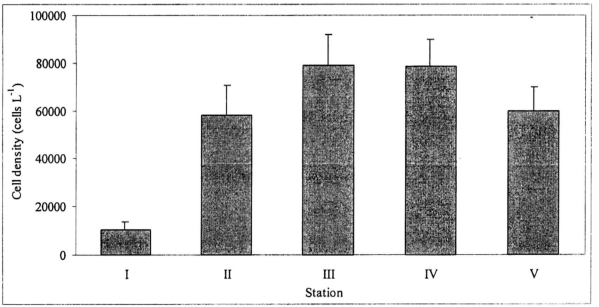

Figure 31. Mean values of cell density for each station.
Error bars denote standard error.

Figure 31 shows the mean cell density ranging from 14080 cells L^{-1} to 79119 cells L^{-1}. Station I had the lowest cell density which was significantly different from other stations ($p < 0.05$).

4.2.3 Species richness

Figure 32 illustrates the trends of species richness for the five stations from December 2000 to March 2001. Station I had the lowest value of 0.631 while Station II had the highest value of 1.418 on 10th February 2001.

Figure 33 shows the mean species richness ranging from 0.803 to 1.242. Station I had the lowest species richness which was significantly different from other stations except station II ($p < 0.05$).

4.2.4 Shannon-Wiener's Index

Figure 34 shows a little fluctuation in the H' value except stations I at the initial stage and generally had a similar trend among the stations. The lowest H' value was 0.478 on 6th December 2002 while the highest H' value was 2.014 on 10th February 2002.

Figure 35 shows the mean Shannon-Wiener Index ranging from 0.803 to 1.242. Generally, the index for each station was not significantly different from one to another.

4.2.5 Chlorophyll-a

Figure 36 shows the trend of chlorophyll-a which had the lowest (0.0004 $\mu g\ L^{-1}$) and the highest (0.0044 $\mu g\ L^{-1}$) on 24th and 10th March 2001 respectively.

Figure 37 shows the mean chlorophyll-a ranging from 0.0009 mg L^{-1} to 0.0023 mg L^{-1}. Stations II and III had significantly higher chlorophyll-a concentrations than stations I, IV and V ($p < 0.05$).

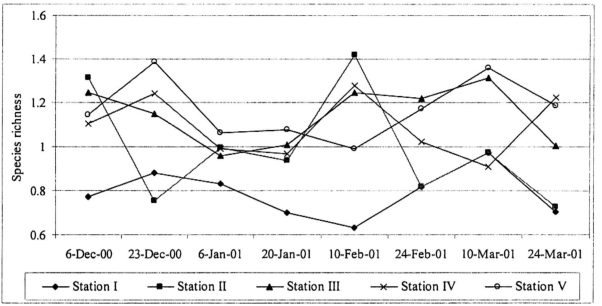

Figure 32. Species richness for each station

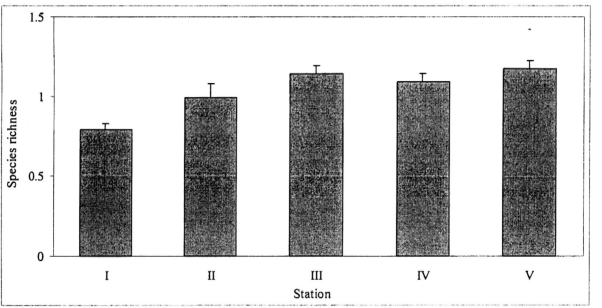

Figure 33. Mean values of species richness for each station.
Error bars denote standard error.

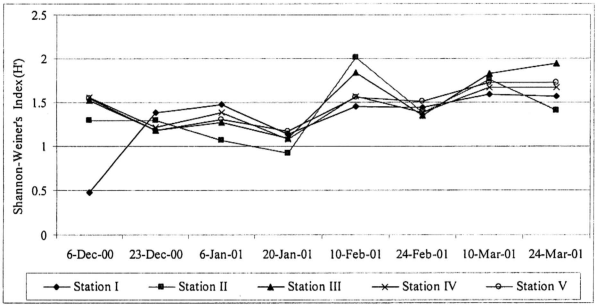

Figure 34. Shannon-Wiener's Index for each station

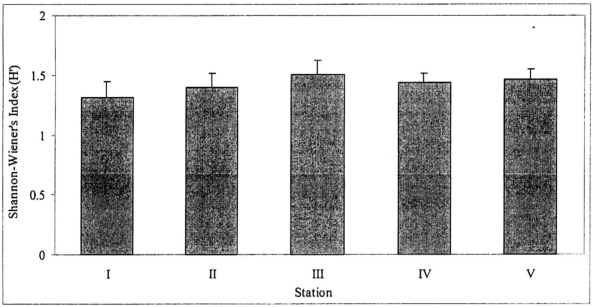

Figure 35. Mean values of Shannon-Wiener's Index for each station.
Error bars denote standard error.

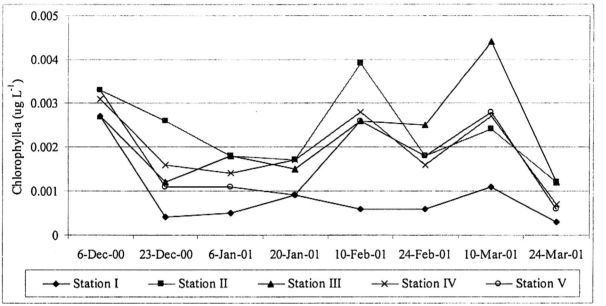

Figure 36. Chlorophyll-a for each station

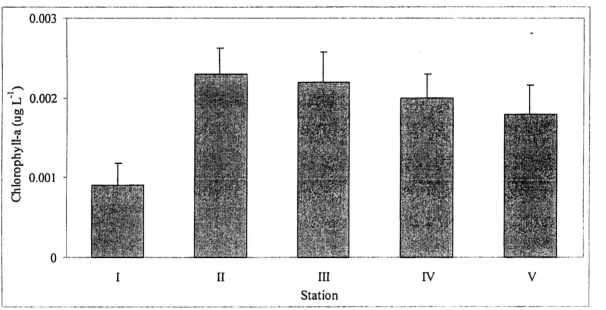

Figure 37. Mean values of chlorophyll-a for each station.
Error bars denote standard error.

4.3 Frequency

Table 3 lists the frequency (%) of each species for the five sampling stations. 15 species were detected at all the five stations which recorded 100%. The other 12 species appeared in one to four stations which recorded 20% to 80%.

Tables 4 to 8 show the frequency (%) of each species for the eight sampling occasions at each station. The number of species recorded 100% at each station ranging from four to nine species. However, only *Navicula* sp. and *Trachelomonas* sp. were detected on each sampling occasion and at each station.

4.4 Two-way ANOVA

Two-way analysis of variance (ANOVA) of all measured parameters indicated that variance of data was influenced by spatial (station) and temporal (time of sampling) factors. The spatial factor was significant at $p < 0.05$ for conductivity, silica, chlorophyll-a, cell density and species richness. But temporal factors at significant level of $p < 0.05$, were temperature, pH, conductivity, dissolved oxygen, dissolved orthophosphate, ammoniacal nitrogen, chlorophyll-a, cell density and Shannon-Wiener's Index (Appendix 3).

4.5 Multiple regression

Multiple regression analysis was carried out to determine and describe the nature of relationship between one dependent variable and two or more independent variables. In this analysis, chlorophyll-a, cell density, species richness and Shannon-Wiener's Index were treated as dependent variables while other variables (temperature, pH, conductivity, dissolved oxygen, secchi depth, dissolved orthophosphate, ammoniacal nitrogen and silica) were treated as independent variables. The results of the multiple regression

analysis are summarised in Table 9. One or more of these independent variables (conductivity, secchi depth and/or silica) influenced the dependent variables (cell density, species richness and Shannon-Wiener's Index).

4.6 Cluster analysis

Figure 38 shows the results of cluster analysis on environmental variables (temperature, pH, conductivity, dissolved orthophosphate, ammoniacal nitrogen and silica). Two main clusters were identified; the first cluster (station I) and the second cluster (stations II, III, IV and V).

Figure 39 shows the results of cluster analysis based on four biotic variables (chlorophyll-a, cell density, species richness and Shannon-Wiener's diversity index). Two main clusters were identified; the first cluster (station I) and the second cluster (stations II, III, IV and V).

Figure 40 shows the results of cluster analysis performed on the species composition. Two main clusters were identified same as above but the exact grouping of the sub-clusters was different. The first cluster (station I) and the second cluster consists of sub-cluster 1 (stations II and IV) and sub-cluster 2 (stations III and V).

Table 9. Results of multiple regression analysis

Variable	Chlorophyll-a	Cell density	Species richness	Shannon-Wiener's Index
Temperature				
pH				
Conductivity				* p = 0.004640
Dissolved oxygen				
Secchi depth		* p = 0.002130		
Dissolved orthophosphate				
Ammoniacal nitrogen				
Silica		* p = 0.000583	* p = 0.010701	

Note : * - significant relationship ($p < 0.05$) between dependent and independent variables

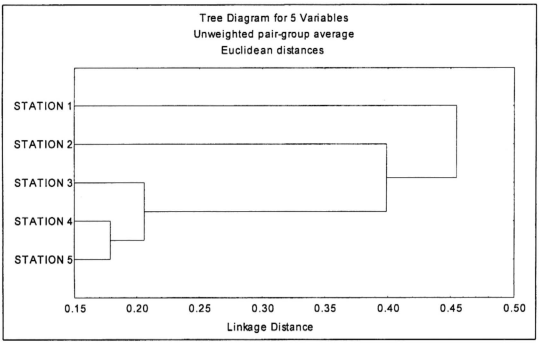

Figure 38. Cluster analysis based on average environmental variables

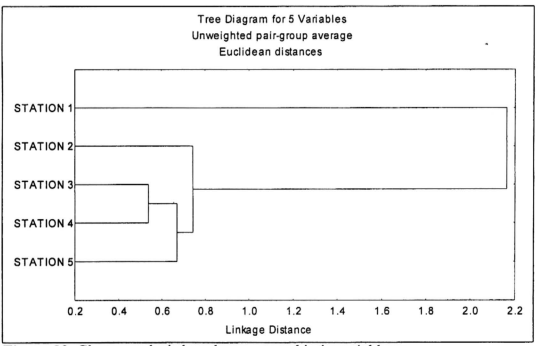

Figure 39. Cluster analysis based on average biotic variables

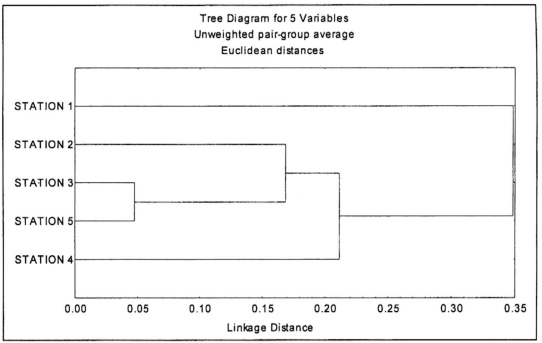

Figure 40. Cluster analysis based on phytoplankton species composition