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ENVI 102
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A Study of Water Quality in Eph's Pond

I. Project description. This project is basically a study monitoring, over a four-week period, the water quality of Eph's Pond with respect to the following quantities: temperature, dissolved oxygen, bacterial content, algal growth, and the filtering capacity of the pond and wetland system, that is, the concentrations of specific ions at inlets and outlets to the pond. I will look at these quantities both with respect to their changes over the sampling period and in comparison to the values established during the study of pond chemistry and microbiology that we performed in February, with my primary focus on the levels of bacterial contamination of the pond over the sampling period. I will include lots of fun graphs and maps.

II. Methods of sampling and analysis.

1. Sampling. I chose the location indicated on Figure 1 to sample from mainly because it was easily accessible from the shore of the pond while still being fully in open water and therefore representative of the open-water area of the pond. The water depth there was approximately 20 centimetres. The samples were collected from a depth of approximately 10 cm below the water surface. Three samples were collected each week, on April 13, 19, 26, and May 4. Although I had planned to, I collected no samples during the week of May 8 because the equipment for bacteriological testing was no longer available. On April 25, I collected samples from the two major inlets to the pond that I was able to find and from the pond outlet, all of which are indicated on Figure 1. A third inlet is shown in grid square 10-D of Figure 1 (which is based on the survey we performed in January) but this inlet was not active in the spring and all the water in this area was stagnant. These inlet and outlet samples were analyzed for bacterial content and specific ion concentration. On May 4, I collected one sample from Inlet 1 and tested it for bacterial content.

2. On-site analysis. At each weekly sampling, I recorded the air and water temperatures and measured the dissolved oxygen

concentration of the water with the DO meter from Bronfman 165, which usually worked properly, with the exception of the first week, on April 13, when I don't think it was working due to miscalibration.

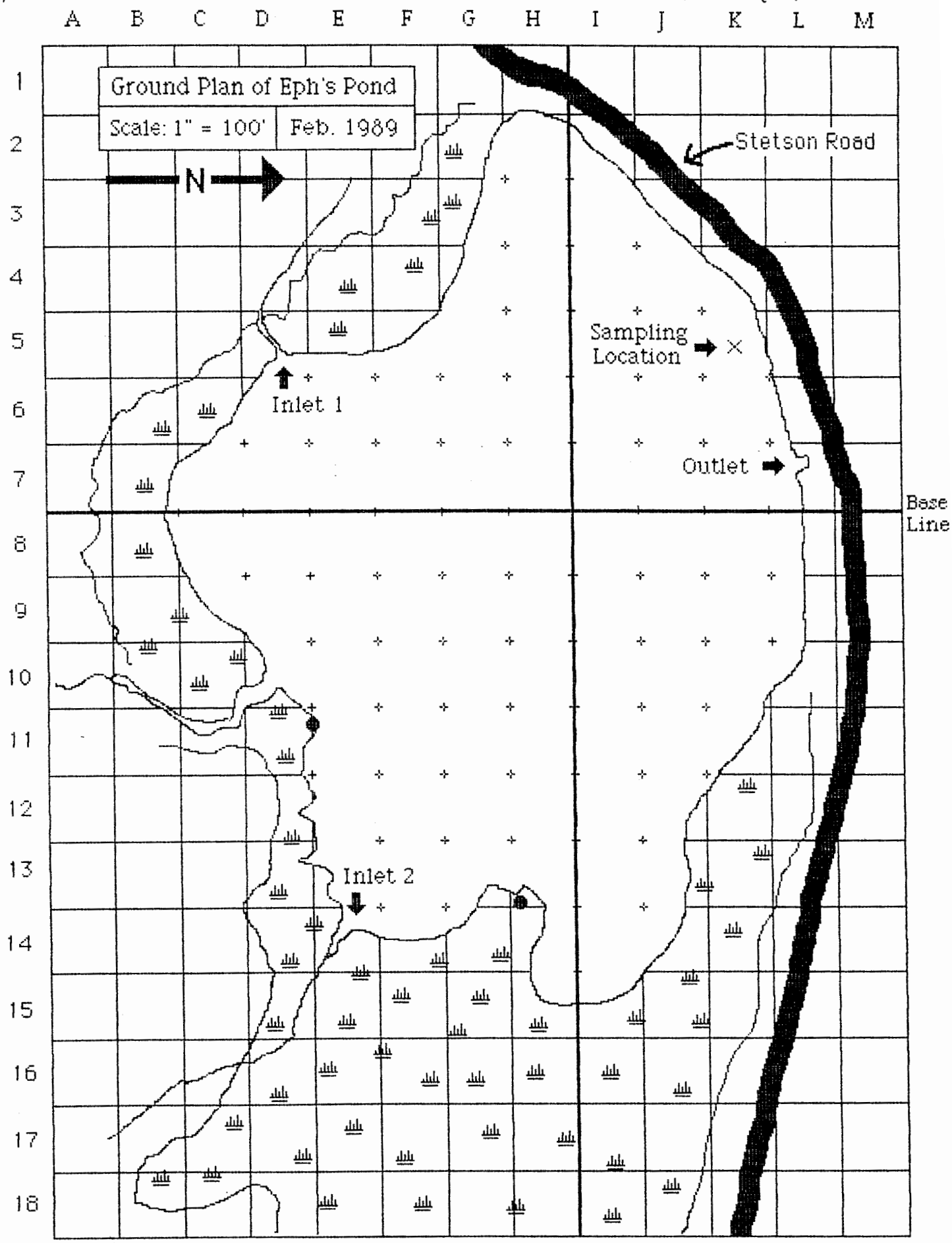
3. Bacteriological analysis. I analyzed each sample that I took in accordance with our standard method of bacteriological testing. The dilutions that I used for each sample are noted with the data. No sample sat in the refrigerator for more than 2 days before being tested for bacteria. I tested some samples twice as controls for the accuracy of my testing procedure. This is also noted in the data. Each sample was tested for total and fecal coliform populations.

4. Specific ion concentrations. I used the IC in accordance with the standard procedure for using it to test for ions. I diluted samples to either 1 in 10 or 1 in 20. Some samples were run through the IC at two different dilutions in order to look more closely at ions that would either peg or not appear at certain dilutions. This is all noted in the data.

5. Algae. I discovered fairly early in this project that I lacked both the necessary experience and the enormous amount of time that performing accurate quantitative counts of algal population requires. Therefore, I do not have any quantitative measurements of algal population. However, I did at least look at the algae every week and make some rough statements about the relative amounts during the sampling period.

FIGURE 1

FIGURE 1



III. Data.

Table 1
Data sampled on location

Week	1	2	3	4
H_2O temp, °C	7	15	17	16
DO, mg/l	-	10.5	12.5	12.5
Air temp, °C	8	11	22	25

Weather:

Week 1- Overcast. Drizzle. Wind 10-15 mph E.
Week 2- Partly cloudy, wind 0-5.
Week 3- Sunny. Wind 5-10 mph NW
Week 4- Sunny. Wind 0-5 mph.

Notes:

1. The reading the DO meter gave me for Week 1 was around 14.5 mg/l. I think this is a fairly ridiculous value given the weather(rainy) and the amount of life in the pond area that week(not much), and am inclined to throw it out as miscalibration or misuse of the meter.

Figure 2 - Basic Sampling Data

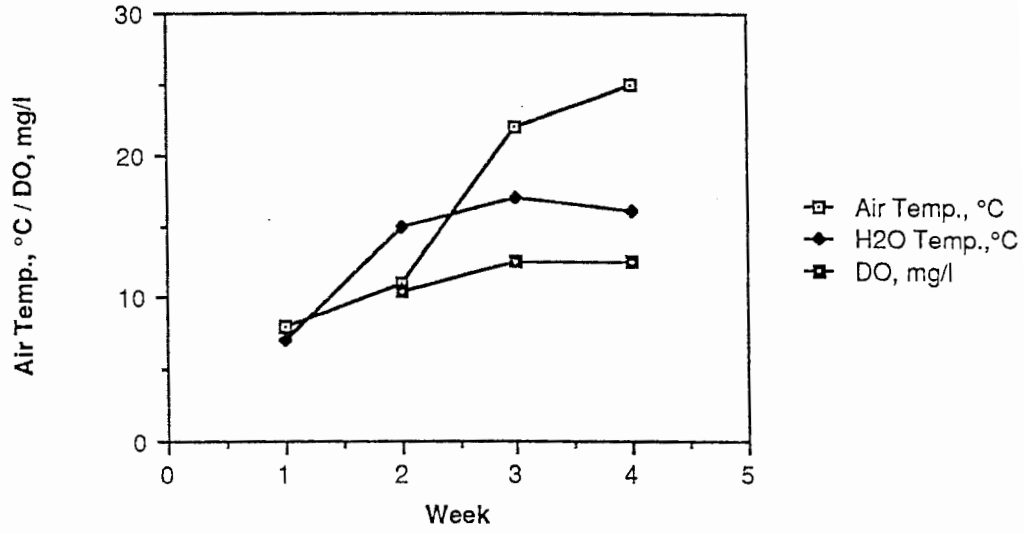


Table 2
Bacteriological Analysis

All numbers refer to individual bacteria per 100 ml of sample.

		Total Coliform	Fecal Coliform
Week 1 -	Sample #1	20	0
	#2	40	0
	#3	20	0
	#4	12	0
	Average	23	0
Week 2 -	Sample #1	2	0
	#2	10	0
	Average	6	0
Week 3 -	Sample #1	16	0
	#2	32	0
	#3	14	0
	Average	21	0
Week 4 -	Sample #1	>100	10
	#2	≥100	16
	Average	>100	13

Inlet and outlet samples taken during Week 3:

Inlet 1		TNTC	152
Inlet 2		TNTC	220
Outlet -	Sample #1	12	0
	#2	8	0

Sample from Inlet 1 taken during Week 4:

Inlet 1	670	64

Notes:

1. Most of these values were computed by filtering 50 ml of sample and multiplying the number of bacteria found by 2. The only exceptions to this are the samples taken from IN-1 during Week 4, when 10 ml of sample was filtered for the total coliform test and 25 ml for the fecal test.

2. Where ">100" or "TNTC"(Too Numerous To Count) are given, it was impossible to count the number of colonies on the filter because of the density and overlap of the colonies. In the cases where this appears above, the exact number of bacteria is probably unimportant because none of the other values are even near that high.

Table 3
Specific Ion Concentrations

All values are given in mg/l.

3.1-Results from 4/25/89

		Cl^-	NO_3^-	SO_4^-
Inlet 1 - Sample	#1	105.6	16.0	31.6
	#2	OS	12.8	32.2
Inlet 2		53.7	0	14.3
Outlet - Sample	#1	60.8	0	20.6
	#2	OS	0	21.1

No phosphates appeared in any sample.

3.2-Results from 2/89

	Cl^-	NO_3^-	SO_4^-	PO_4^-
Inlets (average)	136.1	0	40.76	11.26
Outlet (average)	105.3	0	14.00	0

Notes:

1. Where "OS" (Off Scale) appears in the table the concentration of the specific ion "pegged" the IC program and was too high to be measured. Where this occurred, the same sample was tested at a weaker dilution to get a value for the specific ion that pegged.

2. The 2/89 results are taken directly from the data sheet from the pond chemistry tests done in February.

~~ABLAKE~~ : RESULTS of POND SAMPLING DONE FEB. '89

TABLE 4 [SEE ~~MAP~~ FOR SAMPLING LOCATIONS FIGURE 3]

BACTERIA / 100 ml SAMPLE

Name	Lab day	Sample	pH	TotColif	FecalColif	
E.Highston	Tues	IN-1-1		0	7	1. SAMPLES TAKEN from INFLOWS TO EPN's POND
J. Dye	Wed	IN-1-2	8.06	7	0	
		IN-2-1	7.70	17	0	
		In-2-2	7.76	30	0	
		IN-3-1	8.09		0	
		IN-3-2	8.05	2	0	
Inflows		Average	7.98	10.80	1.16	
G. Nagy	Tues	I-1-1	5.96	3	0	2. SAMPLES TAKEN from ICE ON POND
S.Foster	Tues	I-1-2	6.19	9	22	
H.Christof	Wed	I-2-1	7.00	0	0	
G.Blaine	Tues	I-2-2	6.25	1	1	
		I-3-1	6.85			
S. Martin	Wed	I-3-2	7.05	10	0	
		I-4-1	6.98	0	0	
P. Kahn	Tues	I-4-2	6.50			
A. Conley	Wed	I-5-1	6.40	1	0	
D.McQuaig	Mon	I-5-2		40	0	
S.Kim	Tues	I-6-1	6.70	2	0	
		I-6-2	6.82	1	0	
K.Modeslitt	Mon	I-7-1	7.30	3	0	
J.Snierson	Tues	I-7-2	6.68	0	0	
Ice		Average	6.67	4.25	1.91	
D. Rhods	Mon	Out-1	8.62	4	0	3. OUTFLOW SAMPLES
C.Whitaker	Wed	Out-2	8.72	14	0	
Outflow		Average	8.67	9.00	0.00	
A. Session	Wed	P-1-1	8.16	15	1	4. SAMPLES TAKEN from OPEN WATER IN THE POND
V. Poche	Mon	P-1-2	8.47	1	0	
M. Hayes	Tues	P-2-1	8.45	4	0	
J.Ryden	Tues	P-2-2	8.70	0	0	
H. Art	Mon	P-3-1	8.15	0	0	
P.Kahn	Wed	P-3-2	8.10	2	1	
E. Rogers	Mon	P-4-1	8.68	40	0	
S.Bhagwan	Wed	P-4-2	8.60	56	6	
D.Finkelst	Wed	P-5-1	7.68	234	0	
A. deSanno	Wed	P-5-2	7.86	118	0	
		P-6-1	8.27	30	0	
D.Tweney	Wed	P-6-2	8.30	31	0	
D.Schleein	Wed	P-7-1	8.02	1	0	
D. Toder	Wed	P-7-2	8.50	1	0	
Pond		Average	8.16	38.64	0.28	
D.Bellin	Mon	Spr-1	7.68	1006	497	5. SAMPLES TAKEN from SPRING
P. Sedgwic	Tues	SPR-2	7.88	6010	860	
Spring		Average	7.85	3508.00	678.50	

~~Appendix~~ C, p. 2.

TABLE 4

ALL CONCENTRATIONS IN PPM

Sample	Cond	calcium	magnesium	sodium	chloride	sulfate	nitrate	phosphate
In-1-1		31.0	13.4	4.10	14	67.8	0	21
In-1-2	310	41.7	15.0	5.60	13.2	11.8	0	0
In-2-1	520	61.0	22.6	7.60	22.4	81.4	0	23.4
In-2-2	510	78.9	25.0		23.0	27.4	0	8.6
In-3-1	1400	118.6		400.0	200	30.4	0	5.8
In-3-2	1440	133.8	30.0		544	25.8	0	8.8
Inflows	836.00	77.50	21.20	104.32	136.10	40.76	0.00	11.26
I-1-1	17.5	2.1	0.18	1.08	2.84	1.90	2.33	0.83
I-1-2	4.7	4.3		1.05	2.77	2.04	1.72	0.78
I-2-1	12.0	1.3		0.38	1.38	0.59	0.83	0
I-2-2		1.1	0.29	0.24	1.17	0.57	0.73	0
I-3-1		6.4		0.86	2.05	2.28	1.40	1.24
I-3-2	37.0	6.0		0.85	2.44	7.07	3.39	5.22
I-4-1	23.0	2.9		0.69	66.2	33.0	29.4	14.2
I-4-2	32.0	3.6		0.72	3.81	1.62	1.52	0.73
I-5-1	24.0	3.4	0.75	0.51	1.64	1.85	1.64	1.22
I-5-2	15.8	3.8	0.92	0.58	30.0	35.6	27.8	1.07
I-6-1	18.0	4.0		0.58	1.68	1.67	1.36	0.73
I-6-2	18.0	4.2	0.84	0.56	1.83	1.71	1.50	0.81
I-7-1	23.0	2.2		1.18	63.4	17.4	14.0	0
I-7-2	10.5	2.3		1.13	3.21	1.48	1.27	0.70
Ice	19.62	3.40	0.59	0.74	14.60	7.76	6.34	1.96
Out-1	490	48.3	12.4	44.0	103.4	13.6	0	0
Out-2	460	41.7	15.0	45.5	107.2	14.4	0	0
Outflow	475.00	45.00	13.70	44.75	105.30	14.00	0.00	0.00
P-1-1	535	48.3	10.6	50.0	130.0	14.4	0	0
P-1-2	564	50.0	15.2	54.2	130.2	14.6	0	0
P-2-1	252	27.0		7.50	22	10.4	0	0
P-2-2	255	27.0	11.6	9.1	22	10.4	0	0
P-3-1	245	25.1	12.0	5.8	16.0	9.4	0	0
P-3-2	250	21.0		5.5	17.2	84.0	0	25.8
P-4-1	215	27.0	8.8	5.7	17.2	9.0	0	0
P-4-2	240	35.5	10.2	6.6	16.8	9.4	0	0
P-5-1	300	38.0	11.2	4.20	186	24.8	0	4.8
P-5-2	300	52.1	21.0	5.6	11.6	13.4	0	0
P-6-1	340	50.2	19.8	7.6	20.2	15.2	0	0
P-6-2	375	56.3	18.4	8.1	22.8	68.8	0	21.0
P-7-1	390	35.5		34.2	73	12.2	0	0
P-7-2	395	41.6	12.4	29.4	70.6	11.8	0	0
Pond	332.57	38.18	13.74	16.67	53.97	21.98	0.00	3.68
Spr-1	700	99.3		55.1	130.5	24.0	0	4.6
Spr-2	800	120.5	28.0	57.5	180	25	0	5
Spring	750.00	109.90	28.00	56.30	155.25	24.50	0.00	4.80

FIGURE 3

~~MAP~~ : LOCATIONS SAMPLED IN POND WATER TESTS TO DETERMINE THE FILTERING EFFECT OF THE POND.

IV. Analysis.

1. Bacteria. The concentrations of total coliform bacteria in the pond did not show any coherent trend during the first three weeks of the sampling period, and then increased dramatically during Week 4. The only fecal bacteria that I found also appeared in Week 4. The question that this raises, of course, is that of the accuracy of the testing that I did on 5/5. I am convinced that the results here are fairly accurate for the following reasons. First of all, the results for the two samples agree with each other extremely closely. It is unlikely that any contamination that occurred after I took the samples would be this consistent. Also, the sample from Inlet 1 that I tested at the same time as the two pond samples in question did not show a higher count that the previous week's sample from the same location. This argues against contamination during the testing that I did that day, as it seems that if I contaminated the first two samples I tested I would also contaminate the third. If I accept these data as accurate, then, a significant surge in the level of bacterial contamination of the pond occurred between Weeks 3 and 4.

I am inclined not to place too much importance on the increase in total coliform count in Week 4. Looking at the results of the pond testing done in February, there is a very large amount of variation between different samples for different areas of the pond. The lack of consistent mixing of the pond water due to the low amount of flow through the area suggests that the concentrations of bacteria would not necessarily be uniform over the whole area. There would, however, be more consistent stirring of the pond waters during the spring due to both wind on the water surface and convection resulting from greater daily temperature changes, so the results would be more representative of the entire pond in the spring. The sudden appearance of fecal bacteria does strongly indicate an increase in contamination, given their complete absence during Weeks 1-3.

I can propose several possible reasons for this increase in bacterial contamination. First, it is possible that some localized contamination of my sampling location occurred, specifically that some animal may have deposited feces near the sampling location. Since the samples were taken from a spot several meters away from dry land, however, this seems possible but not likely. Another obvious reason is simply the rise in the water temperature of the pond. As the water temperature increases, the pond becomes a more attractive environment for the growth of bacteria, specifically for the fecal bacteria which survive better at higher temperatures. This does

account for its presence only in Inlet 1 which is the inlet into which most of the campus runoff finds its way to. There are no large fertilizer users in the area to the east of the pond that feeds the Inlet 2 area, and no nitrate appeared in Inlet 2.

3. Sulfates decreased at the inlets and increased at the outlet between winter and spring. Assuming that the major source of sulfates in surface water around here is acid rain, these changes can be explained as follows. During the winter, the ice on the lake and the fact that all the precipitation was in the form of snow would not allow contaminants from the precipitation to enter the pond water except at the inlets, where the lack of ice cover would allow the precipitation to melt and release its contaminants, in this case sulfate ions, into the inlets. Therefore, the concentration of sulfate would be high at the inlets into which a lot of the precipitation was running off the ice, but not very much total contamination would be able to get into the pond because of the few inlets, causing the concentration in the whole pond and the outlet to be low. In the spring without ice on the pond, contaminants from precipitation would enter the whole pond evenly and be less concentrated in the inlets, but the total amount that got into the pond would be greater and the concentrations would be higher in the pond and at the outlets. We see this in the fact that sulfates are lower at Inlet 2 than at the outlet, indications that a lot of sulfate is going directly into the pond (in the form of precipitation) rather than coming in from the inlets. The discrepancies in sulfate between winter and spring fit this model fairly well. Sulfates were also lower in Inlet 2 than in Inlet 1, probably because a greater amount of precipitation is channeled directly into Inlet 1(the runoff from the campus)

4. Reasonable amounts of phosphate were present in pond inlets during the winter but I found none in the spring. Phosphate being a useful and fairly scarce(around here) ion to biological systems[1], it seems likely that the increased amount of biological activity in the pond area in the spring is simply soaking up the phosphate as soon as it gets into the water anywhere. This also seems to have occurred in the winter--no phosphates left the pond, although some came in at the inlets--but in the spring it just probably happens much faster.

5. The pond is still functioning to filter out the ionic contaminants that are present in the water passing through it. Levels of chloride, nitrate, and sulfate were lower at the outlet than at at least some of the inlets. In comparison to the filtering effect that we

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[1]This information comes from a comment made by D. Dethier during a class.

found in February, where we saw significant decreases in the levels of all the ions that we tested for, however, the filtering that I observed in the spring was not as consistent. Chloride, for example, was lower at the outlet than at Inlet 1, but higher than the concentration in Inlet 2. Sulfate was highest in Inlet 1 and lowest in Inlet 2 with the outlet value in the middle. (although it is unlikely that sulfate would be filtered very well because the main source of it is directly into the entire pond area rather than originating at the inlet and having to pass through the pond to get to the outlet.) The nitrate present in Inlet 1, however, was completely removed from the outgoing water. It seems therefore that the pond is still functioning to filter ionic contaminants out of the water that passes through it, although not as completely or consistently as it did in the winter. Possible reasons for this include the lack of an ice cover to the pond that seals the pond water off from atmospheric contamination and the increased water turbulence in the spring(see IV, 1, paragraph 2) that would allow less settling out of contaminants.

3. Algae. As I mentioned before, I have no quantitative data for the amount of algae in the pond each week. However, based on my qualitative observations, the amount of algae increased very significantly during the sampling period. The water I collected during Week 4, in fact, contained sufficient algae to give the water a green tinge and make the bacteria filters a pale green color when I ran the samples through them. In the previous weeks I observed no such color. When I looked at the water in the pond during the week of May 8, however, the green tinge was gone, suggesting that the excessive amount of algae in the water during Week 4 was an aberration produced by the large number of sunny days immediately previous to that sampling. This notwithstanding, however, the amount of algae in the water did increase significantly over the sampling period. The increasing amount of algae is also reflected in the DO readings, which show saturation of the water with oxygen during Weeks 3 and 4, indicating the presence of a lot of algae generating oxygen during those weeks. Due to my emphasis in this project on bacteria and my lack of quantitative data on algal population, this is basically all I can say with regard to the algae.

Perhaps the pond is just responsive to it -

V. Summary. Basically, then, I found the following things during this study.

1. There were a few obvious and expected seasonal changes. The temperature of the air and water increased steadily over the month. This is not very surprising. In fact, I expected it to happen. The DO concentration of the water also increased, a fact easily attributable to the increased algae and plant life in the pond. The amount of algae in the pond water also increased significantly.

2. There were several changes in the specific ion chemistry of the pond inlets and outlets between winter and spring. Chloride levels decreased, which is consistent with the decrease in the use of road salt, which is the main source of chloride contamination in surface waters around here. Phosphate disappeared, a fact consistent with the increased biological activity in the pond. Sulfates increased with the input of sulfate directly from acid precipitation into the pond. Significant amounts of nitrate appeared in Inlet 1, a phenomenon probably caused not by any seasonal change but by increased contamination of that inlet from the sewer pipe that leaks into it. (See V, 4) The pond still functions to filter the water that passes through it, although not as consistently for all ions as it did in the winter.

3. Bacterial levels in the pond showed no consistent seasonal change but leaped to very high levels during the last week of the study. This is probably indicative of increased contamination from the leaking sewer pipe that feeds into Inlet 1(see V,4), combined with the higher temperature of the pond water that makes the pond more favorable to bacterial growth.

4. The level of contamination from the sewer pipe that leaks into Inlet 1 has probably increased since the winter. This is indicated by the presence of fecal coliform bacteria in the pond itself and to a lesser degree by the presence of significant nitrate in Inlet 1 (the nitrate could simply come from the spring fertilizing of the campus grass.)

Well done
A