Progress Report: Year 1

Assessment of Phosphorus Concentrations in the Huron River in Response to an Ordinance Banning the Use of Phosphorus-Containing Lawn Fertilizers

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Project Overview

In an effort to improve the water quality of the Huron River and several of its impoundments, the City of Ann Arbor enacted an ordinance in 2006 that restricts the use of phosphorus-containing lawn fertilizers. The action was based in part on expectations that full compliance could reduce phosphorus loading to the Huron River by 22 percent (Anon. 2006).

Baseline concentrations of phosphorus (P) from 2003 to 2005, before implementation of the ordinance, have been documented by Ferris and Lehman (2008). Those authors made an assessment of the variability associated with dissolved and particulate P as well as other analytes at six sites (Fig. 1) within the middle reach of the Huron River upstream from the outfall of Ann Arbor's wastewater treatment plant.

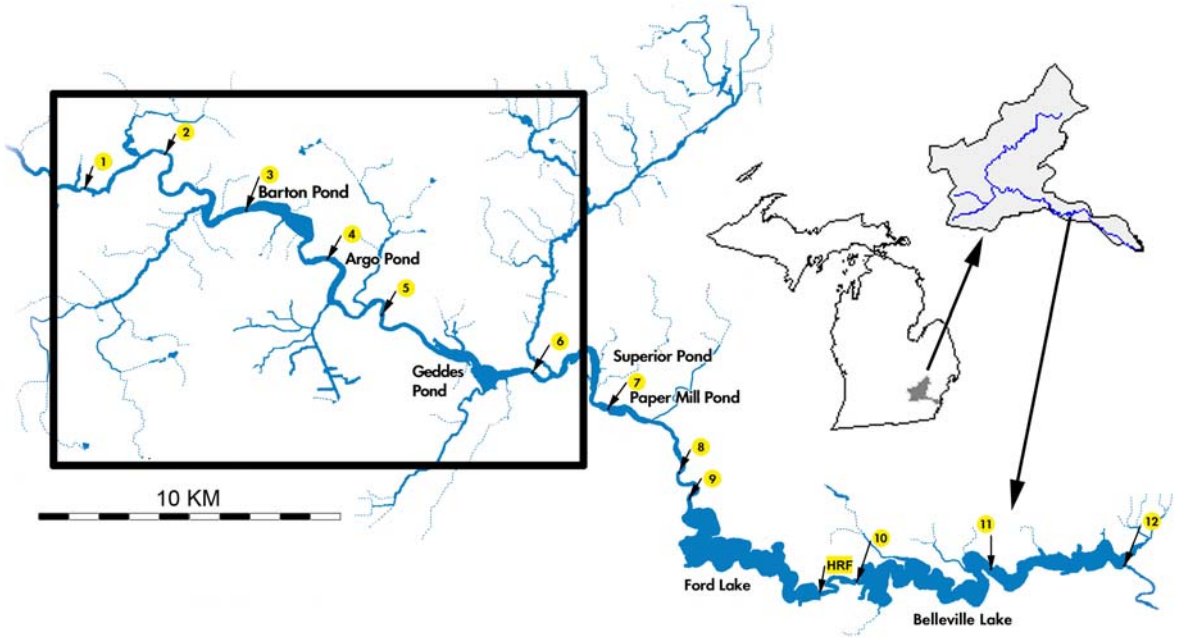

Figure 1. Study site of Ferris and Lehman (2008) enclosed by rectangle. Sampling locations are indicated by arrows and numbers. Sites 1, 5, and 6 are the subject of this report.

Based on the variance in concentrations measured from 2003 to 2005, Ferris and Lehman were able to calculate the sampling effort that would be required to detect changes of any specified magnitude. For a 25% change in total phosphorus (TP), detection would require a time series

of weekly measurements during the summer for one or two years, depending on sampling site. In 2008, the City of Ann Arbor sponsored a 2-year study that would evaluate the efficacy of its ordinance, using the sampling criteria identified by Ferris and Lehman. Here we report the status of that investigation at the end of the first field season.

Methods

Field Sampling

Three sites were chosen for weekly sampling, HR1, HR5, and HR6 (Fig. 1). HR1 was designated the Control site, because it represents the state of the river upstream of the region putatively affected by the Ann Arbor ordinance. HR5 and HR6 (upstream and downstream of Geddes Pond) were designated experimental sites because they were deemed most likely responsive to the P reduction management strategy. Raw and filtered water samples were collected at each site. Filtered water was obtained on site using a Millipore™ disposable groundwater filter capsule of 0.45 μm pore size. Surface temperature was also recorded at each sampling site using an infrared thermometer.

Laboratory Analysis

Upon return to the laboratory, filtrate was immediately analyzed for soluble molybdate-reactive phosphorus (SRP) according to the methodology of Strickland and Parsons (1972). Additional filtrate and raw water samples were treated with 1% potassium persulfate and oxidized at 105 C for 2 h. The resulting digests were analyzed for dissolved P (DP, filtrate) or total P (TP, raw water) using the SRP procedure. For SRP and TP, three replicates were measured at each site. For DP, two replicates were measured at HR1 and HR5 and 3 replicates were measured at HR6. Sample means and standard deviations (SD) were calculated for each determination and measurements were repeated if the coefficient of variation (CV = standard deviation/mean) exceeded 0.05.

Statistical Analysis

Concentration data were logarithmically transformed prior to statistical testing because the data were known to exhibit lognormal frequency distributions. One-tailed independent samples t-tests were used for statistical analysis of SRP, DP, and TP to test the hypothesis that P concentrations have declined with respect to the reference baseline period (2003 to 2005). Weekly measurements in 2008 were grouped by month. Measurements from 2003 to 2005 were likewise aggregated by month. T-tests were performed for each month and each nutrient analysis, contrasting 2008 values against the reference data set. Based on criteria explained by Ferris and Lehman (2008) for optimizing both Type I (alpha) and Type II (beta) statistical error, the Type I threshold probability for rejecting the null hypothesis (i.e., no difference between 2008 and reference years) was set to 90% confidence ($\alpha = 0.1$).

Further, in an effort to improve statistical detection power, we performed one-way analysis of variance contrasting P concentrations at each site by month to see if data from the entire sampling period could be pooled.

Results

SRP concentrations for the months of April to September in 2008 were not significantly lower than reference values at any site (Table 1). For DP, a statistically significant decrease in concentration was detected at HR5 in June and at HR6 in September (Table 2). TP concentrations were significantly lower in 2008 than in 2003 to 2005 in both May and June at HR5 and in May, July, August, and September at HR6 (Table 3). One-way analysis of variance

comparing P concentrations across all months revealed that monthly means were significantly different (α = 0.05) such that data could not be reliably pooled for the entire season.

Table 1. Mean SRP concentrations in 2008 and from 2003 to 2005 at three Huron River stations. NS means that 2008 values are not significantly lower than reference values.

Month	Site	µM P 2003-2005	µM P 2008	Probability
April	HR1	0.05	0.11	NS
	HR5	0.05	0.09	NS
	HR6	0.07	0.07	NS
May	HR1	0.17	0.13	NS
	HR5	0.16	0.10	NS
	HR6	0.15	0.13	NS
June	HR1	0.15	0.27	NS
	HR5	0.21	0.24	NS
	HR6	0.15	0.28	NS
July	HR1	0.22	0.22	NS
	HR5	0.27	0.30	NS
	HR6	0.24	0.30	NS
August	HR1	0.20	0.30	NS
	HR5	0.29	0.29	NS
	HR6	0.25	0.24	NS
Sept	HR1	0.17	0.29	NS
	HR5	0.27	0.30	NS
	HR6	0.17	0.21	NS

Table 2. Mean DP concentrations in 2008 and in 2003−2005 at three Huron River stations. Statistically significant probabilities and percent reductions are reported. NS means that 2008 values are not significantly lower than reference values.

Month	Site	µM P 2003-2005	µM P 2008	Probability	% Reduction
April	HR1	0.22	0.27	NS	
	HR5	0.25	0.27	NS	
	HR6	0.28	0.27	NS	
May	HR1	0.43	0.31	NS	
	HR5	0.45	0.30	NS	
	HR6	0.45	0.33	NS	
June	HR1	0.45	0.51	NS	
	HR5	0.56	0.47	**0.096**	16
	HR6	0.53	0.49	NS	
July	HR1	0.52	0.54	NS	
	HR5	0.62	0.66	NS	
	HR6	0.74	0.68	NS	
August	HR1	0.51	0.59	NS	
	HR5	0.63	0.68	NS	
	HR6	0.79	0.60	NS	
Sept	HR1	0.41	0.47	NS	
	HR5	0.56	0.54	NS	
	HR6	0.60	0.47	**0.071**	22

Table 3. Mean TP concentrations in 2008 and in 2003−2005 at three Huron River stations. Statistically significant probabilities and percent reductions are reported. NS = 2008 values are not significantly lower than reference values.

Month	Site	µM P 2003-2005	µM P 2008	Probability	% Reduction
April	HR1	0.60	0.63	NS	
	HR5	0.67	0.66	NS	
	HR6	0.87	0.79	NS	
May	HR1	0.80	0.58	NS	
	HR5	0.97	0.58	**0.080**	40
	HR6	1.29	0.74	**0.079**	43
June	HR1	0.91	1.02	NS	
	HR5	0.93	0.77	**0.064**	17
	HR6	1.23	1.10	NS	
July	HR1	1.13	1.16	NS	
	HR5	0.93	0.83	NS	
	HR6	1.45	0.99	**0.049**	32
August	HR1	0.99	0.86	NS	
	HR5	0.82	0.79	NS	
	HR6	1.42	0.92	**0.046**	35
Sept	HR1	0.68	0.88	NS	
	HR5	0.74	0.75	NS	
	HR6	1.08	0.89	**0.004**	18

Discussion

Ferris and Lehman (2008) point out that DP and TP are inherently less variable in the Huron River than is SRP, and that consequently it would be possible to detect changes in concentration for DP and TP with less sampling effort than would be required for SRP. In fact, Ferris and Lehman reported that their median expectation for detecting a 25% change would be 8 years of weekly samples for SRP but only 2 years for TP and 3 years for DP. The initial results of this study are fully consistent with those predictions. In no cases were any reductions in SRP detected at any site from April to June, whereas reductions were detected for both DP and TP at experimental sites.

- Statistically detectable decreases in TP concentration were noted in 6 cases out of 10 at the experimental sites (HR5 and HR6) during the main growing period from May to September (Table 3). The average reduction in concentration for those 6 cases was 31%.

- For DP, reductions in concentration were statistically significant for only 2 cases out of 10 (May to September, HR5 and HR6), although there is a clear trend of reduced monthly mean concentrations at HR6 in every one of those 5 months (Table 2), with the mean reduction being 18%. The probability that such a consistent trend could happen by chance alone is only 0.008.

- Upstream site HR1 appears to be functioning well as a Control site, in that no statistically significant reductions in SRP, DP or TP were noted there.

Data collection and analysis is now complete for Year 1. Statistically significant reductions have been documented for TP and, to a lesser degree, for DP for every month from May to September. Percentage reductions are of the predicted magnitude. We can state objectively with a considerable degree of confidence that phosphorus concentrations were lower in 2008 compared with the reference period (2003 to 2005) and that the reductions were coincident with a City ordinance restricting use of lawn fertilizers containing phosphorus. It would be tempting to conclude that the phosphorus reductions were caused by implementation of the ordinance, and that may indeed be the case. However, we must bear in mind that the ordinance was enacted in the context of public education efforts that encourage citizens to be more mindful of yard waste discharges into storm drains, to exert more diligence regarding buffer strips of vegetation along stream banks, and to exhibit more environmental awareness in general. These multi-faceted efforts make it difficult to isolate a single cause for the changes, but the changes appear to be real.

References

Anon. 2006. Phosphorus. Manufactured Fertilizer Reduction Ordinance. City of Ann Arbor, Michigan, January 2006.

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