Analysis of nutrients and chlorophyll relative to the 2008 fertilizer ordinance in Lee County, Florida

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Abstract Research and qualitative observations suggest that a major contributor to algae growth in stormwater ponds is the nitrogen (N) and phosphorus (P) contained in fertilizers that enter the ponds via runoff from lawns and impervious surfaces. In May 2008, the Lee County Board of Commissioners enacted a fertilizer ordinance with the objective of lessening discharge of nutrients to stormwater ponds. It prohibits applying fertilizers containing N and P during the four wet summer months (June through September). The Pond Watch Program is a citizen volunteer monitoring program that helps understand and manage community ponds. This study examines Pond Watch data to compare N, P and chlorophyll *a* levels in similar urban stormwater ponds during the wet months of 2004 through 2008 (prior to the fertilizer ordinance enforcement) compared to 2009 through 2013 (after enactment). The results showed a statistically significant difference in the reduction of levels between pre- and post-ordinance in total phosphorus and chlorophyll *a.* This was not the case for total nitrogen. The study suggests that the fertilizer ordinance may have had a positive effect on the reduction of nutrient concentrations in some stormwater ponds, which may contribute reducing the abundance of planktonic algae.

Keywords Chlorophyll, fertilizer ordinance, nutrients, Pond Watch, volunteer monitoring

Introduction

During the summer months in southwest Florida, stormwater ponds exhibit from time to time frequent algae blooms (Greening et al. 2014). Crane and Xian (2006) reported that a major contributor to these algae blooms was the increased amount of nitrogen (N) and phosphorus (P) by anthropogenic activities associated with urban sprawl. N and P contained in fertilizer may enter stormwater ponds from lawns and landscapes, runoff from impervious surfaces and water that percolates through predominantly sandy soils. Ultimately, these waters containing excess nutrients may enter natural water bodies and coastal waters (FDEP 2009).

In 2008, Lee County Board of Commissioners enacted a fertilizer ordinance (Lee County Ordinance 08-08) (Lee County Florida 2008) after technical recommendations from the South West Florida Regional Planning Council and several non-governmental organizations (SWFRPC 2007). These laws became mandatory during the wet months of 2009. Among many of the

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Table 1. Nine ponds selected from the Pond Watch Program to evaluate nutrient contents.

No.	Pond Watch ID	Subdivision	Area (ha)	Longitude	Latitude
1	1	Stone Bridge	0.4	−81.896515	26.506573
2	4	Peppertree Pointe	2.1	−81.949689	26.519921
3	14	South Pointe South	2.0	−81.909797	26.547372
4	35	Corkscrew Woodland	7.5	−81.777317	26.424099
5	37	Wellington	2.5	−81.900010	26.502472
6	42	Wyldewood Lakes	0.2	−81.888100	26.562310
7	47	South Wind	3.1	−81.897330	26.485810
8	54	Candlewood Lake	6.3	−81.966610	26.509190
9	57	Caloosa Creek	4.0	−81.969470	26.513330

best management practices, the ordinance prohibits the application of nitrogen (N) and phosphorus (P) (from fertilizers) during the four wet summer months (June 1 through September 30) with the stated objective of lessening nutrients in stormwater ponds and other waters that run into major bodies of water.

The Lee County Hyacinth Control District created the Pond Watch Program in the early 1990s to educate citizens in the management of ponds and aquatic weeds. The program is a citizen volunteer monitoring initiative that involves sampling and analyzing numerous stormwater ponds for water quality chemistry on a monthly basis. This paper examines Pond Watch data to compare the amount of nitrogen, phosphorus and chlorophyll *a* in relation to the implementation of the fertilizer ordinance.

This paper investigates whether or not there is a difference in the concentration of nutrients present in selected stormwater ponds in the summer months of 2009 through 2013 compared to the years before the Lee County fertilizer ordinance was adopted (2004 through 2008).

Methods

Sampling location. The volunteer monitoring program Pond Watch receives water samples for analysis every month from community ponds in Lee County, Florida. In the interest of having a representative sample of ponds for comparison, we selected ponds with the following basic characteristics: 1) pond surface area between 0.2 to 7 hectares; 2) pond depth not greater than 3.6 meters; 3) pond surrounded by single family housing; 4) lawns maintained by the homeowner and/or private landscaping contractors; and 5) water quality data available from 2004 to 2013. Nine ponds met these criteria (locations provided in Table 1).

Sample collection. Samples were collected monthly by volunteers following the sampling protocol of the Pond Watch Program. Chemical analysis of the pond water was conducted at the Water Quality Laboratory of the Lee County Hyacinth Control 3District (DOH Certification # E25945, Florida USEPA ID. FL01214). Total phosphorus (TP) was determined using the ascorbic acid method (Standard Methods SM 4500PE) (APHA 1998). Total Kjeldahl Nitrogen (TKN) was determined using the block digestion procedure (SM 4500ND) followed by the phenolic method of ammonia determination (SM 4500NH3F). Nitrite and nitrate (NOx) were determined using the cadmium reduction method (SM 4500NO3E). The relative total nitrogen (RTN) reported was calculated by adding the TKN and the NOx concentrations. Chlorophyll *a* (Chl *a*) analysis was determined by acetone extraction and with fluorometric analysis (EPA Method 445.0-1 and 446.0) (Arar 1997, Arar and Collins 1997). The data for the pre-ordinance period was from 2004 through

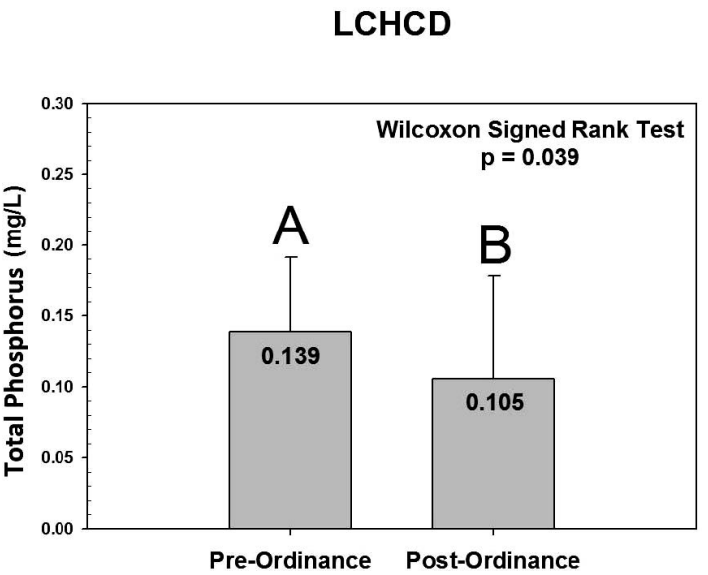

Figure 1. Graphic comparison of Total Phosphorus values pre- and post-fertilizer ordinance.

2008 because TKN analysis was introduced in 2004. The post-ordinance period was from 2009 through 2013.

Statistical analysis. A paired t-test and a Wilcoxon signed rank test were conducted using SigmaPlot 10.0 and SigmaStat 3.5 software (Systat Software 2014) to determine if there was a significant difference between the wet season months (June 1 through September 30) of pre-ordinance and post-ordinance average values for total phosphorus, relative total nitrogen, and chlorophyll *a*. The analyses conducted on the observations combined the data of all nine ponds. However, we also performed statistical analyses for each individual pond since volunteers wanted to answer questions regarding their behavioral change.

Results

There was a statistically significant difference ($P < 0.05$) between the pre- and post-ordinance average for total phosphorus (Figure 1) and chlorophyll *a* (Figure 2) in the water of all nine ponds evaluated. The reduction in the overall combined concentration of total phosphorus (from 0.139 mg/L to 0.105 mg/L) and chlorophyll *a* (from 27.02 μg/L to 17.83 μg/L) was statistically significant. Relative total nitrogen did not present a statistical significant difference ($P > 0.05$) between the pre- and post-ordinance levels (Figure 3).

For total phosphorus, eight out of nine (8/9) stormwater ponds demonstrated a decrease in the concentration of phosphorus when comparing the wet months of pre- and post-ordinance periods (Figure 4). Although not statistically significant, relative total nitrogen in six out of the nine (6/9) ponds showed a decrease in the concentration of nitrogen (Figure 5). All nine (9/9) ponds demonstrated a decrease in the concentration of chlorophyll *a*, which is an indicator of the relative abundance of suspended planktonic algae in the water column (Figure 6).

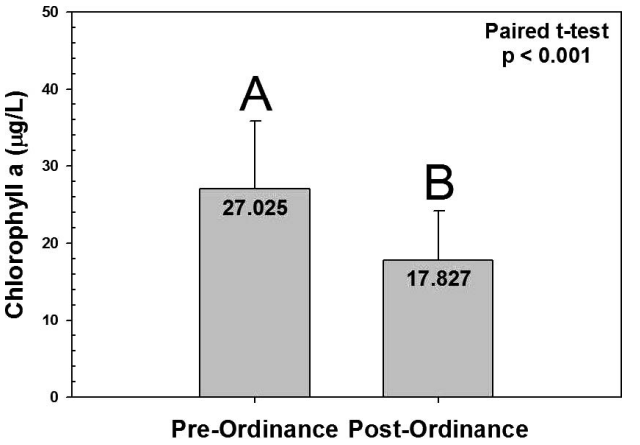

Figure 2. Graphic comparison of chlorophyll *a* values pre- and post-fertilizer ordinance.

Table 2 presents a summary of the nine stormwater ponds evaluated indicating the change (decrease, increase or no change) by pond for each parameter analyzed between the pre- and post-ordinance experimental groups.

We must clarify that the values from Pond 14 may have added a bias error. This pond has been treated between 2009 and 2013 with a special dye (AQUASHADE^{TM}) to minimize light penetration to control underwater submerged plants. This dye consists of small particles that increase the amount of phosphorus present in the water column; therefore, the values of TP increase in this pond.

Discussion

The Lee County ordinance prohibiting the application of N and P in fertilizers during the rainy season from June through September went into effect in May of 2008. The Pond Watch Program of the Lee County Hyacinth Control

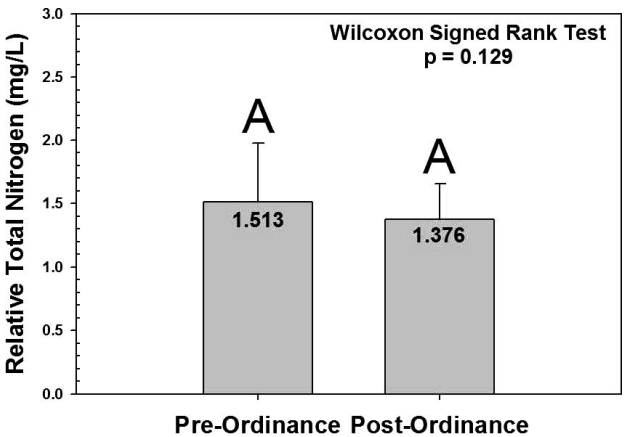

Figure 3. Graphic comparison of relative Total Nitrogen values pre- and post-fertilizer ordinance.

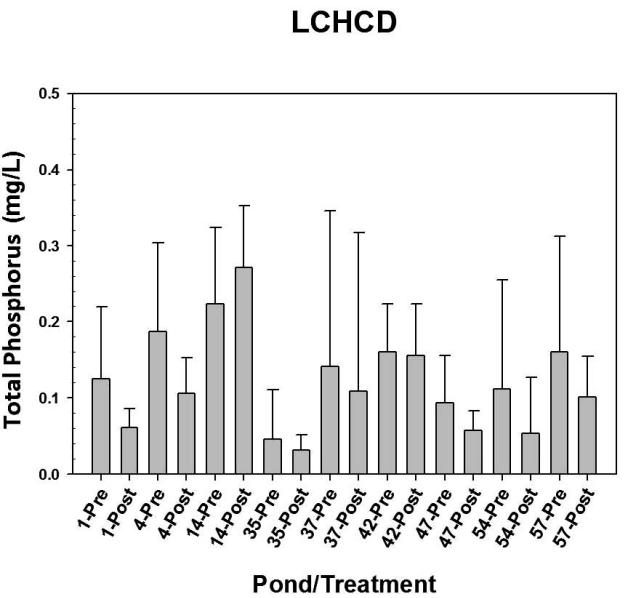

Figure 4. Graphic comparison of Total Phosphorus values pre- and post-ordinance per pond studied.

District has been collecting data in stormwater ponds throughout Lee County since 1992; however, it was only in 2004 when the laboratory added TKN analyses to determine total nitrogen (TN) with complement measurements of other species of nitrogen, such as proteins, ammonia, nitrites and nitrates. Rainfall varies in Florida between the wet months of June through September

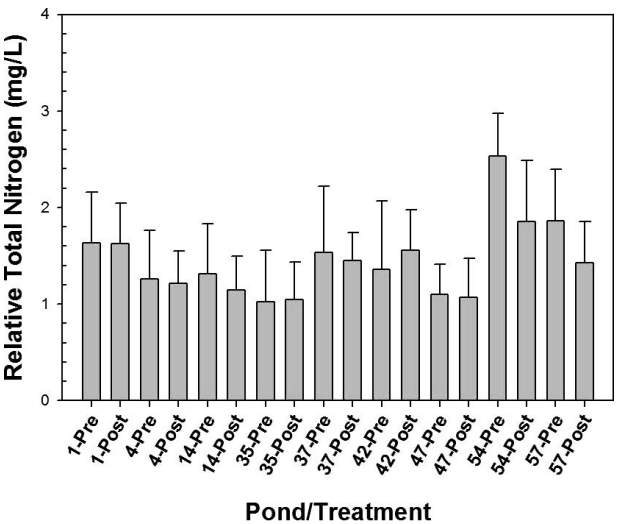

Figure 5. Graphic comparison of relative Total Nitrogen values pre- and post-ordinance per pond studied.

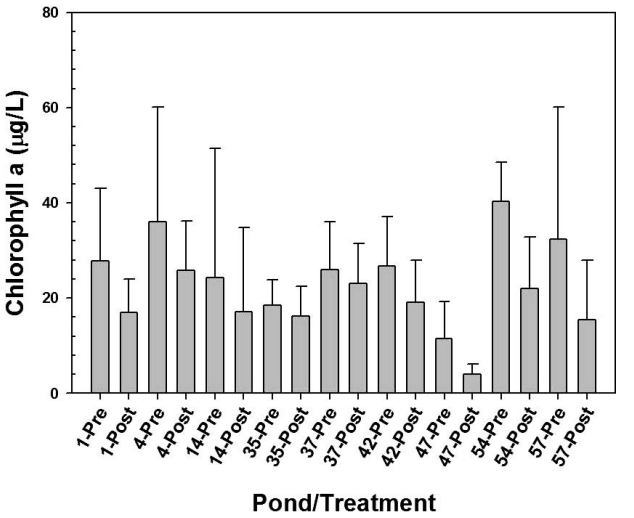

Figure 6. Graphic comparison of chlorophyll *a* values pre- and post-ordinance per pond studied.

as compared to the dry months of October through May (Sculley 1986). Thus, the comparison of pre-ordinance and post-ordinance reflects only the wet months. It has been suggested that the pre-ordinance period was not representative of a normal rain pattern for South West Florida since it registered one of the wettest year (2005) and the driest year (2007) in the study period (2004-2013) (data from the Lee County Rainfall Gauge Data website). However, a statistical analysis between the average rainfall between the wet seasons from 2004-2008 vs. 2009-2013 periods presented no significant difference ($P > 0.05$).

According to the results, total phosphorus (TP) was significantly reduced by 24.5% and chlorophyll *a* was significantly reduced by 34.0%, whereas the reduction for relative total nitrogen (RTN) of 9.2 % was not significant. These statistically significant values demonstrate that the reduction was considerable for the overall values of P and chlorophyll *a*. Furthermore, it was of greater value for the individual communities to see whether their landscape practices had an effect on the condition of the stormwater pond (see Table 2). Home

Table 2. Summary of changes per community.

Pond	Location	TP	RTN	Chl *a*
1	Stone Bridge	DECREASE	No Change	DECREASE
4	Peppertree Point	DECREASE	decrease	decrease
14	South Point S.	increase	decrease	decrease
35	Corkscrew W.	decrease	increase	decrease
37	Wellington	DECREASE	decrease	decrease
42	Wyldewood L.	decrease	increase	decrease
47	South Wind	decrease	decrease	DECREASE
54	Candlewood L.	DECREASE	DECREASE	DECREASE
57	Caloosa Creek	decrease	decrease	decrease

Note: Significant reduction indicated by capital letters.

owner associations, community development districts and neighborhood associations play an important role enforcing and educating their communities (Hartman et al. 2008). According to Greening et al. (2014), one factor addressing the impact in watershed-based nutrient management in Tampa Bay, among many others, was the citizen involvement reducing the residential fertilizer use and collaborative actions with local regulatory programs.

The results of this study suggest that the fertilizer ordinance may have had a positive effect on the reduction of nutrient concentrations in some stormwater ponds, which may have contributed to the reduction of the relative abundance of planktonic algae. We hope that the fertilizer ordinance contributes to the improvement of water quality conditions in runoff water reaching larger water bodies.

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