

Quantifying the Urban and Rural Nutrient Fluxes to Lake Erie Using a Paired Watershed Approach

Introduction

This research quantifies surface water nutrient fluxes to the eastern basin of Lake Erie using a paired watershed approach. Specifically phosphorus and nitrate concentrations are explored, since these nutrients contribute to Harmful Algae Blooms (HABs) that have plagued Lake Erie in the past. Three watersheds that feed Lake Erie were chosen based on land use and areal extent: one small urban, one small rural, and one large rural.

The objectives of this research was to:

- Quantify concentrations of nutrients, observe how nutrient flux varies over seasonal transition, and changes in rainfall.
- Identify major contributors, and explore how differences in land use and watershed area contribute to nutrient loading.

Field Sites

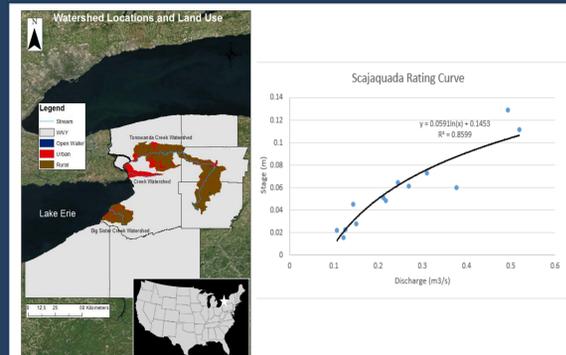


Figure 1. By using the gathered continuous discharge data over time, rating curves were generated for Scajaquada Creek as well as Tonawanda Creek.

Methods

Field Methods:

- Samples were collected using a US-DH59 isokinetic sampler in accordance with standard collection methods [Sylvester et al., 1990]
- Two liters of water were divided, filtered, acidified, and stored in a plastic bottle.
- pH, DO, SC and temperature were all analyzed by using a YSI multi-probe for each sampling date.
- Using the discharge data and the stream stage data gathered from the field, rating curves for each site had been established. As shown in Figure 1 for the Scajaquada stream.



Laboratory Methods:

Nitrogen

- Filtered, un-acidified samples were brought back to the lab and underwent anion chromatography using a Dionex ISC 1000
- A bicarbonate/Carbonate eluent was used, and had maintained an accuracy of within 5%
- By analyzing the area under the peak, the Nitrate concentrations (mg of N/L) were determined.

Phosphorous

- Total phosphorous and Dissolved phosphorous samples (filtered) had undergone Ammonium Persulfate digestion (Standard Methods) to transform the various forms of phosphorous into orthophosphate.
- Orthophosphates from the digestion process, as well as the Dissolved Reactive Phosphorous samples, were analyzed using a spectrophotometer (Genesys 10S) by the Ascorbic Acid colorimetric assay().
- The accuracy was maintained within 1%.

Results

Tonawanda

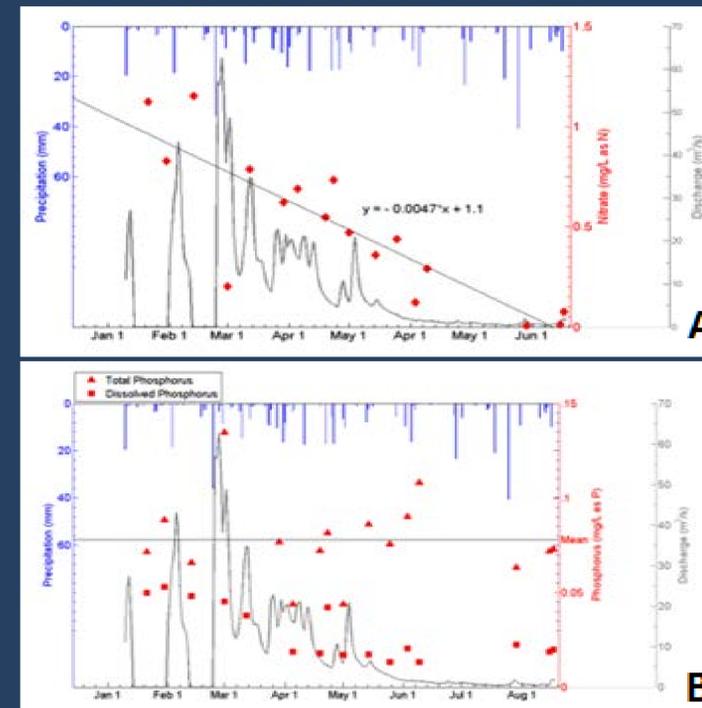


Figure 2. The temporal analysis is represented by the linear trend of concentration and time, which can help to understand seasonal flux. (A) A plot of nitrate concentration, discharge, and precipitation over time. A negative linear trend is observed for nitrate concentrations, implying a decrease of nutrient flux during the seasonal transition. Due to this trend, total mass flux was determined for Tonawanda Creek. (B) Total and dissolved phosphorus concentrations, discharge, and precipitation plotted over time. Mean total phosphorus concentrations were used as the linear trend between concentration and time.

Scajaquada

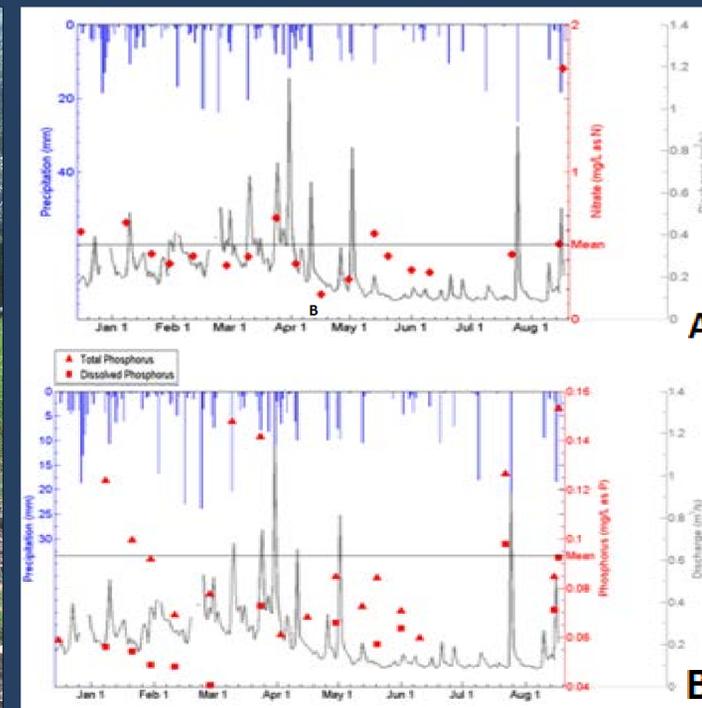
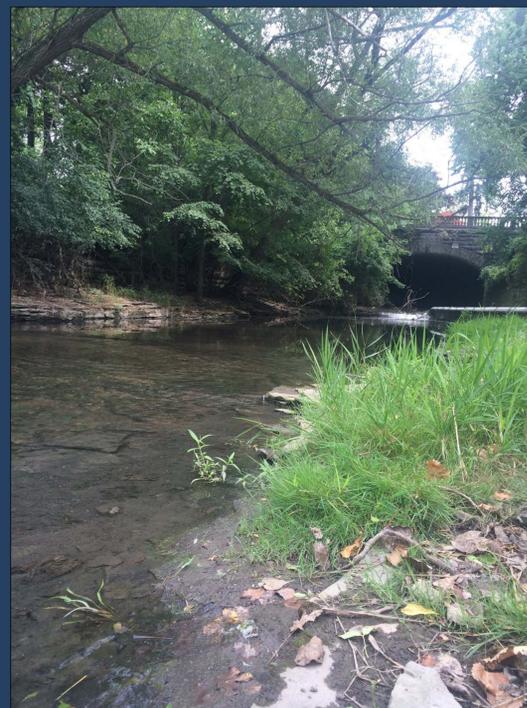


Figure 4. The temporal analysis is represented by the linear trend of concentration and time, which can help to understand seasonal flux. (A) A plot of nitrate concentration, discharge, and precipitation over time. The nitrate flux appears to vary throughout the seasonal transition, as observed by the relatively stable temporal trend. (B) Total and dissolved phosphorus concentrations, discharge, and precipitation plotted over time. Mean total phosphorus concentrations were used as the linear trend between concentration and time. Notably, the dissolved phosphorous flux appeared to remain relatively stable during the seasonal transition.

Tonawanda Flux and Scajaquada Flux

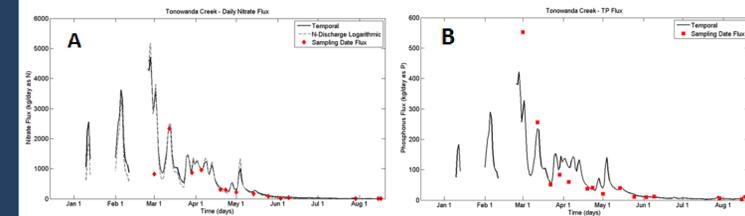


Figure 5. (A) The total nitrate load for Tonawanda Creek. Both the temporal trend (solid line) and logarithmic (dashed line) approximation and are shown on the graph. (B) The total phosphorous load for Tonawanda Creek.

Discussion

- Both the temporal model and the logarithmic flux approximation are similar with one another, as well as with the point-in-time flux (Figure 8) for the Tonawanda Nitrate total flux graph (Figure 5a).
- March of 2016 was the month in which both streams had the highest amount of nutrient flux. Both models had over-predicted flux for this month.
- Tonawanda creek had overall higher levels of nutrient loading, as well as larger nutrient mass flux when compared to that of Scajaquada creek.
- Approximately 90% of Tonawanda's nutrient mass flux had occurred preceding May 1st, indicating that a majority of the flux occurred during the spring season.

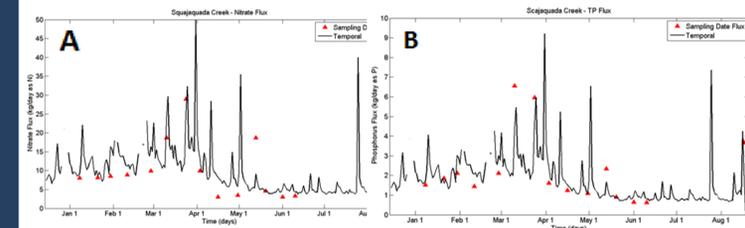


Figure 6. (A) The total nitrate load for Scajaquada Creek. (B) The total phosphorous load for Scajaquada Creek.

Discussion

- While approximately 70% of Scajaquada's mass flux had occurred before May 1st.
- For Tonawanda creek, the nitrate concentration is directly related to discharge which explains the decrease in nitrate concentration in the drier months.
- Dissolved phosphorous concentrations for Tonawanda creek follow a similar trend, and decrease over time.
- While approximately 70% of Scajaquada's mass flux had occurred before May 1st.
- During the summer months, the amount of mass flux for the urban water stream had exceeded that of the large rural stream.
- Scajaquada creek varies less with seasonal affect, and produces a consistent level of nutrient flux over time.
- The nitrate concentration in streams is dependent on high rainfall and high flow conditions for more rural areas.
- Both watersheds show a consistent level of total phosphorous output, which did not significantly vary with seasonal affect.

Conclusion

- Out of the three sub-watersheds analyzed, the large rural stream contributes the most to nutrient loading even after contributions are normalized based on watershed area.
- Tonawanda creek had the highest overall nutrient loading per square meter, as well as the highest mass flux for both nutrients.
- All three streams had produced maximal nutrient loading during March 2016.
- During the winter to spring transition the nutrient flux decreases in both rural streams, while the urban stream nutrient load remained constant.
- The urban watershed continues to transmit a consistent amount of throughout the year, and becomes the main nutrient loading contributor during the dry summer.
- Through the comparison of the wet versus dry conditions, it is predicted that there will be an increase in the amount of nitrate discharge into Lake Erie in the coming years, which has implications for HABs.

Acknowledgements

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