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Using Acesulfame to Determine Septic System Impact to Wisconsin Lakes

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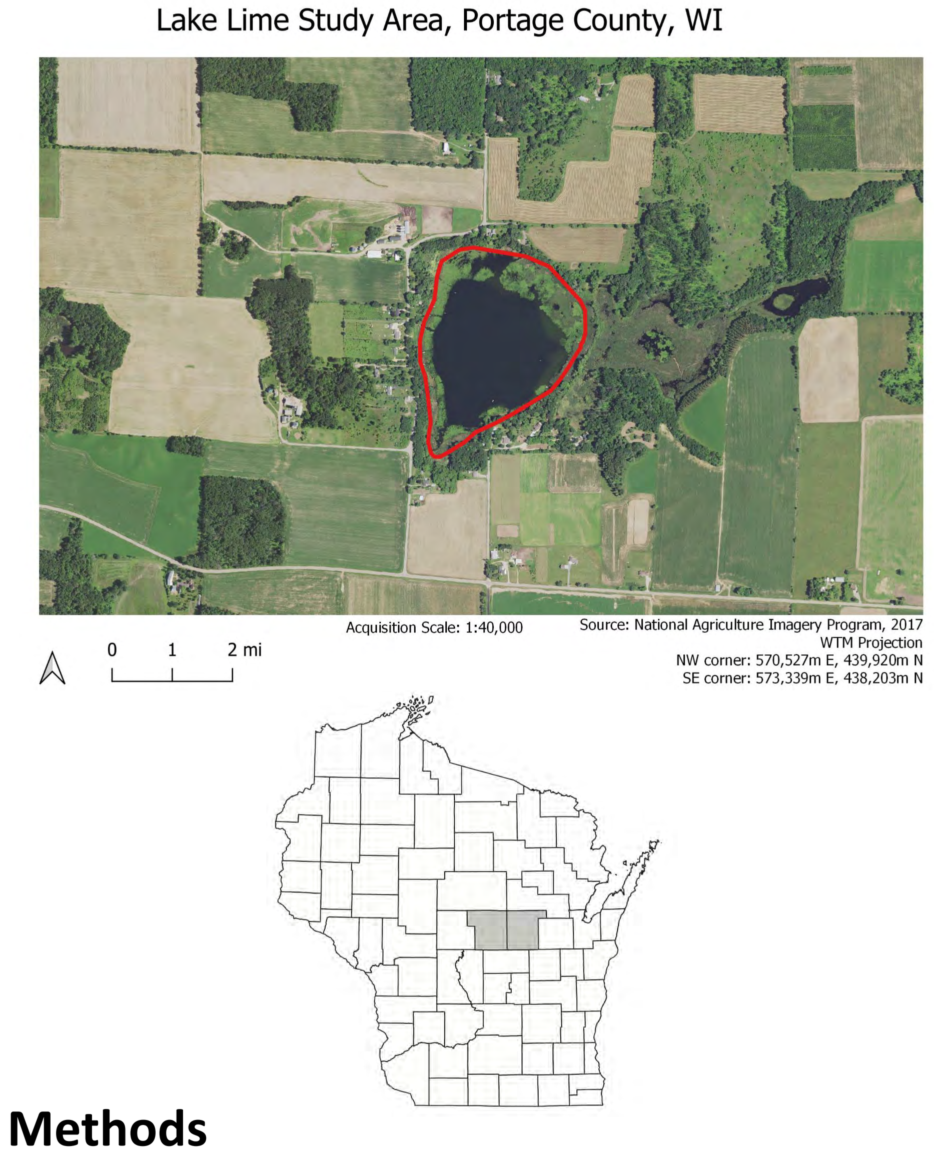
Introduction

Artificial sweeteners have gained popularity as helpful indicators of human waste source contamination of groundwater over the last decade due to their high concentrations and specificity to human wastewater (Roy & Robinson 2020). Sweeteners, such as acesulfame, have a notable resistance to decay that allows them to be found in measurable concentrations in groundwater and surface water (Bujagic et al. 2020). Artificial sweeteners enter the groundwater through septic effluent and are eventually carried to surface waters.

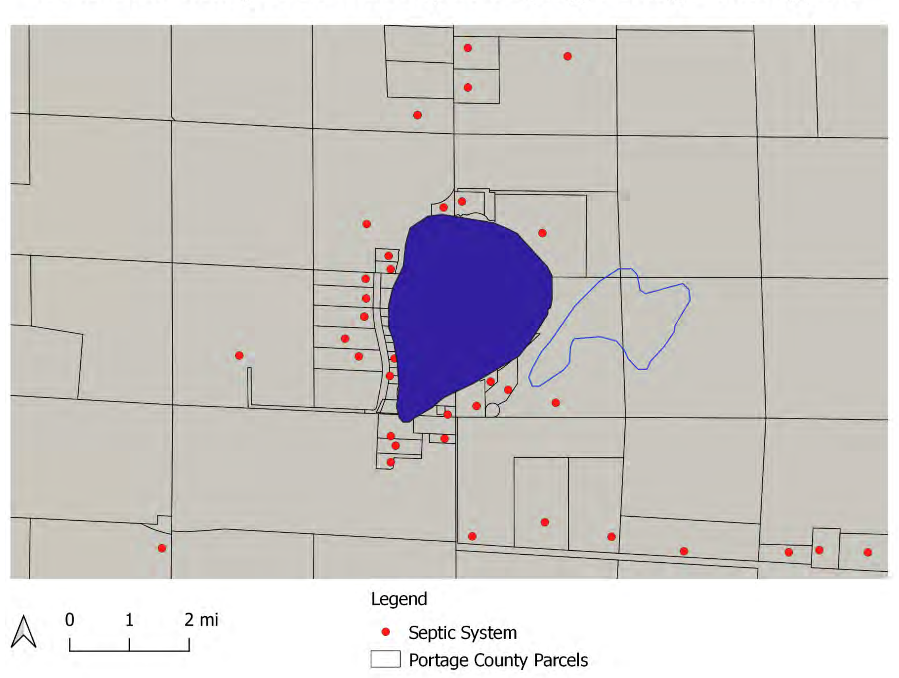
Acesulfame (ACE) has the potential to be a useful environmental tracer but is difficult to analyze. The method we have previously been using to prepare samples for sweetener analysis has consistently yielded spike recoveries of approximately 50% for ACE. With the investigation of a new method, we aimed to find a way to consistently increase ACE yields of spike recoveries in our process.

The purpose of this study is to determine the relative contribution of septic system effluent to the water budget of a lake by measuring the concentrations of acesulfame in lakes in central Wisconsin. A detection of septic contribution to the lakes could be an indication of a nutrient loading source of phosphorus and nitrogen from septic systems to the waterbody which could result in harmful algal blooms and fish kills (Lapointe et al. 2017). We expect to find that lakes with a greater number of septic systems to groundwater inflow rate will have higher concentrations of acesulfame because of a greater septic system contribution to their water budgets.

Lake Lime Study Area, Portage County, WI



Lake Lime Study Area with Septic Display, Portage County, WI



Methods

- Grab samples were collected from seven different lakes in Portage and Waupaca Counties.
- Samples were prepared using 225 mL of lake sample, 150 µL of 1:1 H_2SO_4, and 62.5 µL of benzoylecgonine-D3, the surrogate standard.
- 25 mL of 80.0 g/L solution of ethylenediaminetetraacetic acid (EDTA) in reverse osmosis water was added to each sample after the volume had been acidified to improve recovery in solid phase extraction. This method resulted in approximately 65% spike recovery.
- 100 mL of each prepared sample was extracted using Oasis HLB 6cc (200 mg) extraction cartridges on the Dionex Autotrace 280. Cartridges were pre-conditioned with 3.0 mL of methanol, 3.0 mL of 0.5 N HCl, and 3.0 mL of reverse osmosis water. A 5.0 mL fraction was then collected into a sample tube using methanol.
- Extracts were dried under nitrogen flow in a Turbovap LV at 64-65°C to dryness and reconstituted with methanol.
- Samples were analyzed using an Agilent 6430 Triple Quad liquid chromatograph mass spectrometer (LC/MS) instrument with the Agilent XDB-C18; 1.8 µm; 4.6 x 50mm column.

Image 1. Solid phase extraction of the lake samples by the Dionex Autotrace 280.

Image 2. Sample preparation for extraction.

Results

Acesulfame was detected at each of the investigated lakes. Table 1 shows the ACE concentrations ranged from 11.9 ng/L to 63.4 ng/L. The concentrations were weakly correlated with the number of septic systems once adjusted for the total groundwater inflow into the lake, as shown in Figure 1.

Table 1. Number of surrounding septic systems, total groundwater inflow rate in cfs, septic system count per rate of total groundwater inflow, ACE concentration in ng/L, ACE usage in grams per year, and ACE usage in grams per septic system per year for each of the lakes sampled.

Lake	Septic Number	Groundwater Inflow in cfs	Septic Number/cfs	ACE Conc. in ng/L	ACE Usage in grams/year	ACE Usage in grams/system/year
Onland	21	0.30	70.0	30.7	8.3	0.4
Lime	23	0.47	48.9	63.4	26.7	1.2
Sunset	32	0.13	246.2	40.4	4.7	0.1
Rinehart	42	0.35	120.0	23.7	7.4	0.2
Tree	54	0.63	85.7	11.9	6.7	0.1
Stratton	106	3.45	30.7	17.3	53.5	0.5
Helen	122	0.36	338.9	35.4	11.4	0.1

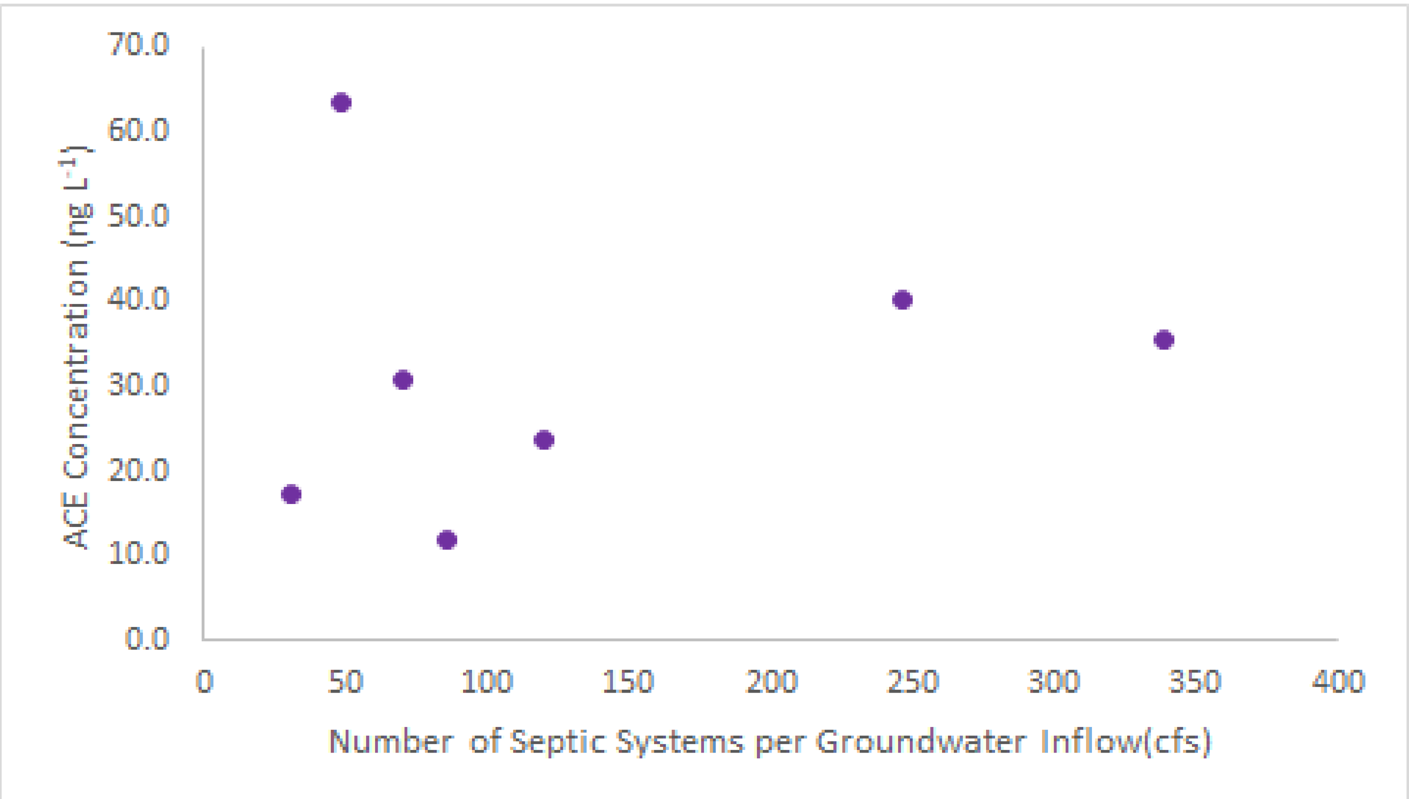


Figure 1. Septic contribution of ACE in ng/L due to the number of septic systems in each lake's estimated watershed per total groundwater inflow in cfs for each of the lakes sampled.

Discussion

- The relationship between the number of septic systems per groundwater inflow and ACE concentrations suggests septic contribution to a lake's water budget that increases with the ratio of septic systems to total groundwater inflow rate.
- Variation among ACE and septic number/cfs relationships could be due to seasonal usage of lake homes, varying sizes of watersheds, and varying locations of watershed contribution to a lake.
- High ACE concentrations at Lake Lime in relation to the low septic number to groundwater inflow ratio could be due to the potential of septic system use variations in ACE concentrations such as more permanent residents or more consumption of products containing ACE.
- The flow rate and concentrations were used to estimate a mass of ACE per septic system per year. The average annual ACE contribution was 0.4 grams/system/year. This is approximately 6% of the anticipated annual ACE usage (Belton et al. 2020) which is consistent with seasonal use and only partial development of the parcels on these lakes.

Future Research

- Continue to investigate methods with higher ACE recovery percentages while improving the process of EDTA addition, essential for chelating minerals for acid analytes (Blair et al. 2013)
- More detailed ACE plume identification of septic effluent
- Eventually use the results of more detailed investigations to better understand the role of septic systems in nitrogen and phosphorus content in the lakes

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Acknowledgements: We would like to thank the Water and Environmental Analysis Lab for encouraging undergraduate student research and experience. This material is based upon work supported by the U.S. Geological Survey and the State Water Resources Research Institute Program 104B through the Wisconsin Water Resources Institute. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Geological Survey.