Nitrate contaminant tracing in surface and groundwater in the Great Miami River Watershed: Environmental Isotope Approach
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Introduction
- This project focuses on using a stable isotope dual tracing method of δ¹⁵N and δ¹⁸O Analysis (¹⁵N-NO₃⁻ and ¹⁸O-H₂O) to trace nitrate contamination to its regional sources.
- Additional boron (δ¹⁰B) analysis is used to distinguish natural from anthropogenic sources.
- We focus on the Great Miami River Watershed (GMRW) in Southwest OH. Here, more than 40% of streams do not meet Ohio’s water quality standards (OEPA, 2012).
- Approximately 70% of the region is dedicated to agricultural use and nitrate contamination is a major threat to surface water quality (MCD, 2018).
- Nitrate sources include:
  - Anthropogenic (municipal waste, human waste, synthetic fertilizers)
  - Natural (animal waste, soil content)
- Nitrate contamination affects:
  - All trophic levels
  - Human health and Water quality
  - Watershed management costs
- Preliminary sampling was conducted to establish regional stable isotopic signatures in Summer 2017 (Fig 3A, 3B).
- Additional sampling at outfall, groundwater, and river sites was conducted in Fall 2018 to observe primary nitrate sources for surface water resources within the GMRW

Methodology

Field Work
- Summer 2017 sampling sites chosen based off varying land usage (agriculture, urban, natural) (Fig. 1).
- Surface water collection
  - Collected along the Great Miami, Mad, and Stillwater Rivers
  - Refrigerated to prevent bacterial action and processed using 0.8/0.2 µm sterile filters.
- Soil Samples
  - Collected using an auger at multiple depths per location (Fig. 1).
  - Soil logs for each site were combined and washed for further nitrate analysis.
- Isotopic Analysis
  - Summer 2017 solid and water samples were analyzed with an Isotope Ratio Mass Spectrometer and Elemental Analyzer in continuous flow mode and KNO₃ precipitation method, respectively.
  - Fall 2018 Samples were analyzed using a bacterial denitrification method.
- ¹⁰B/¹⁰B isotopic ratios measured by Negative Thermal Ionization Mass Spectrometry (NTIMS)

Results

I. Regional Isotopic Signatures

Figure 3a. Nitrogen isotopic signatures for different land usage sites. WWTP represents wastewater treatment samples.

Figure 3b. Oxygen isotopic signatures for different land usage sites. WWTP represents wastewater treatment samples.

II. Separation of Anthropogenic and Natural Sources

Figure 4a. Boron (δ¹⁰B) and nitrogen (δ¹⁵N) from wastewater, manure, and natural sites.

Figure 4b. Boron and (δ¹⁰B) and oxygen (δ¹⁸O) from wastewater, manure, and natural sites.

III. GMRW Isotopic Signatures

Figure 5a. Nitrogen isotopic signatures for the GMRW.

Figure 5b. Oxygen isotopic signatures for the GMRW.

Discussion
- Our data falls within a reasonable range of previously collected data for nitrogen and oxygen nitrate isotope signatures for various contamination sources with some regional variability (Fig. 6).
  - Our results show a distinct low δ¹⁵N for commercial synthetic fertilizers (0.4±4‰) and high δ¹⁵N for animal and human waste (13.0±1.3‰).
  - River samples δ¹⁰B values lie within a range of human and animal waste.
  - Groundwater δ¹⁰B values suggest that the nitrates might have been derived from soil organic matter or synthetic fertilizers.

Nutrient Management Strategies
- Limiting usage of highly-enriched commercial fertilizers
- Implementing local legislation similar to Lake Erie Western Basin Watershed (OSU Agriculture, 2018). Fertilizer and manure application should be restricted during the following:
  1. Snow-covered or frozen soil
  2. When the top soil layer, up to 3 inches, is saturated from precipitation
  3. When local weather forecast in the application area has greater than a 50% chance of precipitation within the next 2 days, exceeding half an inch of precipitation within a 24-hour period
- Reevaluate effluent nutrient limits and make local regulations more strict as the current standards allow for damage to regional

Future Work
- Since the δ¹⁵N values of collected river samples lie within a range of human and animal waste, additional boron analysis is needed to determine if the nitrates are contributed from anthropogenic or natural sources.
- Results of this project provide a regional baseline for nitrate contaminant source tracing but further sampling and isotopic analysis will work to enhance state and local water quality and nutrient management planning.

References

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