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Stream microbial nutrient limitation is mediated by sediment texture, not stream size or aridity

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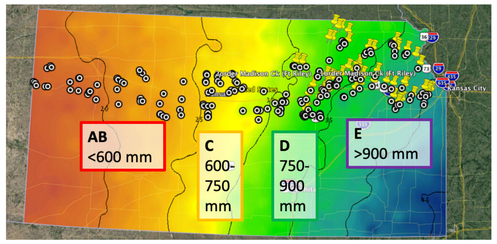
INTRODUCTION

Changes in land-use and precipitation create differences in availability of nutrients like nitrogen (N) and phosphorus (P) to streams, from land inputs such as fertilizer. Increasing nutrients can lead to broader impacts on water quality and health of aquatic systems.

130 sites were sampled across the state of Kansas across 4 precipitation regions from arid (AB) to mesic (E). Nutrient limitation of microbiota was assessed using extracellular enzymatic assays (EEA). The purpose was to learn the impacts of agricultural land use (the next step of the study) and precipitation on microbial activity and in-stream nutrient demands.

Sites Surveyed



Sediment and water samples were collected in triplicate at every site.

PREDICTIONS

Aridity As precipitation decreases (from east to west across the state), we predicted more N and P nutrient limitation will exist, because the lack of precipitation would decrease runoff, and therefore decrease land connectivity and nutrient loading. We expected P to be most affected, because of link to physical transport.

Stream order (or the relative stream size) More N and P limitations downstream were predicted, with more distance from terrestrial nutrient sources occurring in higher stream orders therefore decreasing the potential for nutrient inputs.

Lastly If not the factors we thought, then what controls microbial activity and nutrient demand?

Example of site location and a demonstration of sampling.

Lab bench during hydrolytic enzyme assay prep. Including 96 well plates and substrates.

METHODS

Sediment sample measurements collected include;

- **Extracellular Enzymatic Activity (EEA)**
  - Hydrolitic Enzyme Assays
- **Organic matter as Ash Free Dry Mass (AFDM)**
- **Water Chemistry Analysis**
  - pH
  - Water Temperature
  - Other chemistry to be conducted at a later date

Enzymes Assayed

Alpha-glucosidase (AG): Hydrolyze glucose from starch to obtain labile C

Beta-glucosidase (BG): Hydrolyze glucose from cellulose to obtain labile

N-acetylglucosaminidase (NAG): Hydrolyze amino sugars from microbial cell walls to obtain labile N and C

L-aminopepidase (LAP): Hydrolyze peptides from organic molecules to obtain labile N

Phosphatase (Phos): Hydrolyze phosphate from organic molecules to gain soluble P

Xylosidase (XYL): Degrade hemicellulose to obtain labile C

Cellobiohydrolase (CBH): Degrade cellulose to obtain labile C

Ratios of activity: Reflect relative demand for limiting nutrients

ex: (BG)/(NAG+LAP) or (BG)/(Phos)

CONCLUSION

Unexpectedly, more than stream order or aridity, stream microbial nutrient demands are influenced by organic sediment nutrient supply, and the primary texture of the stream bed. There tended to be more organic matter in more arid stream sediments, indicating a relationship between the amount of precipitation and microbial nutrient demand that is not related to nutrient inputs through the stream water.

Original hypotheses stemmed from thinking land connectivity would significantly impact nutrient inputs, however sediment type was the strongest driver and was not predicted to be. Further analysis is needed to determine the effects of agricultural land use, as well as what role water chemistry may play on the sediment microbial nutrient dynamics.

Acknowledgments

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RESULTS

Stream order was found to be an insignificant driver in nutrient limitation

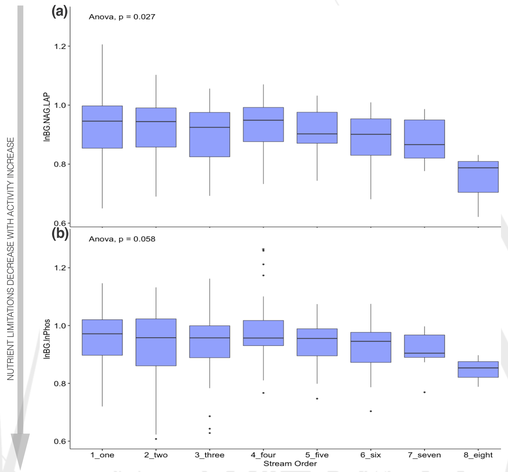

Figure 1: Predictions made indicated that we expect to see more nutrient limitations down stream, because terrestrial nutrient inputs would be less. Neither **(a)** Nitrogen or **(b)** Phosphorus indicated significant variation across stream order.

Nutrient limitations were significantly different amongst mesic and arid zones

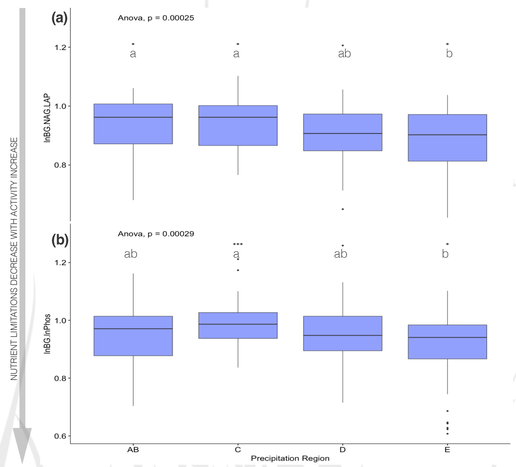

Figure 2: **(a)** The data indicates that sites located in regions AB and C are lower in enzymatic activity than region E, indicating there is lower N limitations out west in relation to eastern precipitation regions. **(b)** P limitations shows significant variation in region C indicating there is less limitation in this region than the others.

Organic Matter was seen to be more significant in regions with higher precipitation

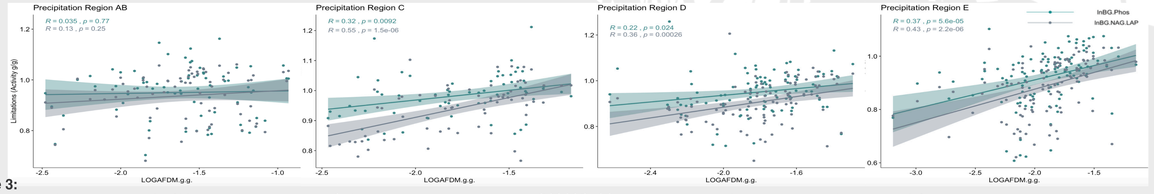

Figure 3:
There is a correlation between AFDM and activity in regions further east indicated by graphs **(b)(c)(d). (a)**There is a no correlation in precipitation region AB, indicating there may be some underlying effects in this regions limiting the effects of organic nutrient supply found in the sediment.

Nutrient Limitation in relation to Precipitation Region based on Sediment Texture

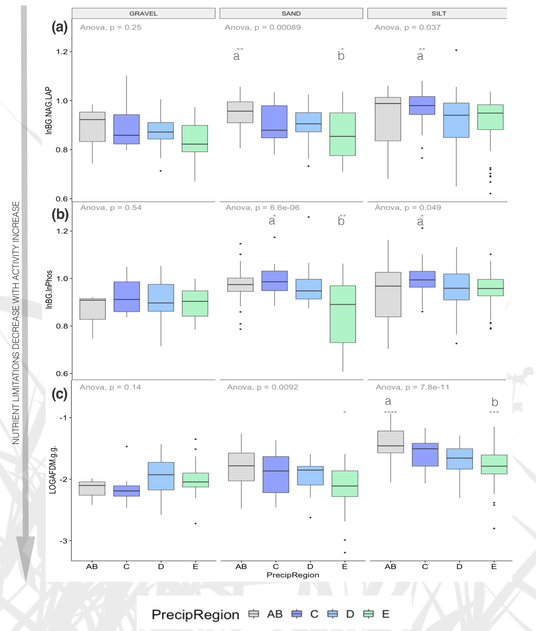

Figure 4:
(a) N enzyme activity is lower silt and sand compositions showing a slight decrease in regions AB with sand, and C with silt. Indicating these sites are more nitrogen limited. **(b)** Phosphatase enzyme activity is lower in primarily silt and sand compositions showing slight decrease in activity in regions C. This indicates P is less limited in aquatic systems contained within region C. **(c)** Organic matter is higher in primarily silt compositions showing significant variation between regions AB and E, indicating western Kansas aquatic systems contain higher amounts of organic matter.

Sediment texture strongly influenced the correlation of nutient limitations and organic matter

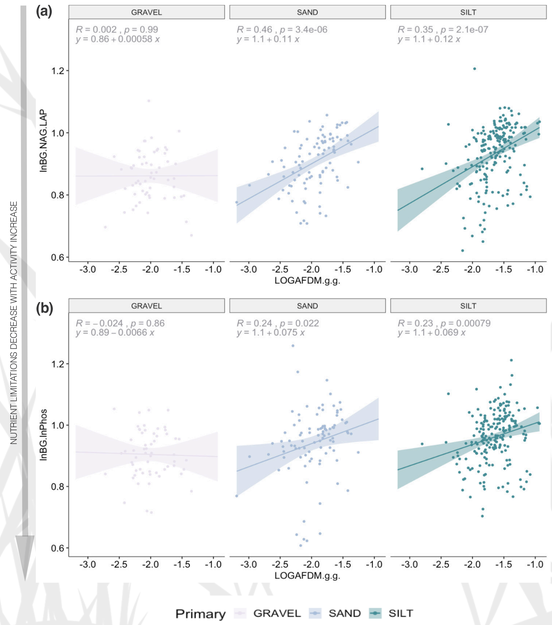

Figure 5:
The correlation of AFDM and nutrient demands is indicated in silt and sand primary compositions. Positive correlations exist showing that the increase in AFDM shows a decrease in activity, therefore limitations are decreasing. The relationship between AFDM, primary compositions, and activity levels in seen in both **(a)** nitrogen, and **(b)** phosphorus nutrient demand trends.