Evaluating Machine Learning Techniques for Estimating Nutrient Concentrations in Streams and Hydroponic Systems based on UV-Vis Absorption Spectroscopy

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Introduction

Water Analysis Challenges

- Knowledge gained is limited by spatiotemporal data resolution. Yet,
  - Watersheds must be managed for a variety of land uses
  - Food production systems must be managed under uncertain conditions.

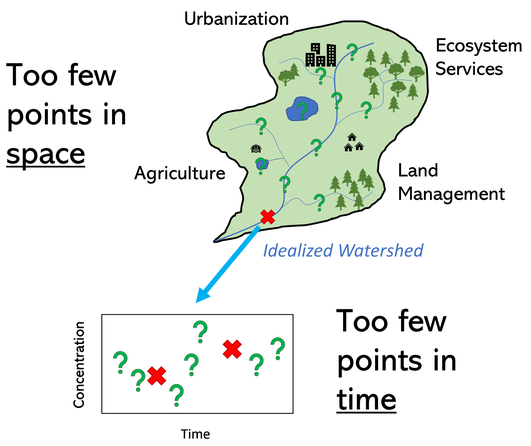

Figure 1. Illustration of insufficient spatiotemporal resolution

"The collection of high frequency water quality data is key to making the next leap in hydrological and biogeochemical sciences." [1]

Water Analysis Techniques

- There is a variety of techniques for collecting water quality data.
- UV-Visible absorption spectroscopy (UVAS) is a promising water analysis method for increasing spatiotemporal resolution.

Table 1. Comparison of common methods for water analysis.

	GS-LA	ISEs	UVAS
Temporal Resolution	Low - Moderate	High	Low - High
Number of Parameters	High	Low	Low - High
Cost	High	Moderate	Moderate - High
Labor	High	Low - Moderate	Low - Moderate
Technical Difficulty	Moderate - High	Low - Moderate	Low - Moderate

"…facile portable data logging devices easy to be carried and handled for quantitative on-site optical analysis should be developed as the alternative platforms for…monitoring [of environmental contaminants]." [2]

Experimental Methods

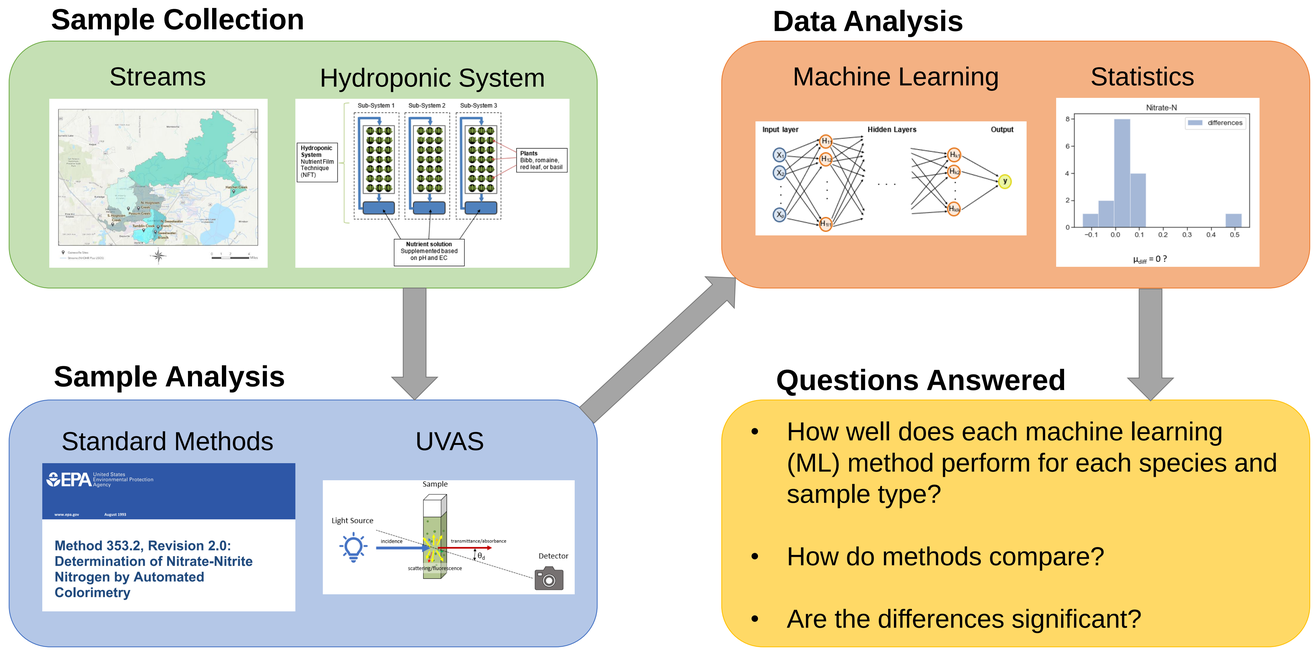

Figure 2. Outline of procedures.

Results - Streams

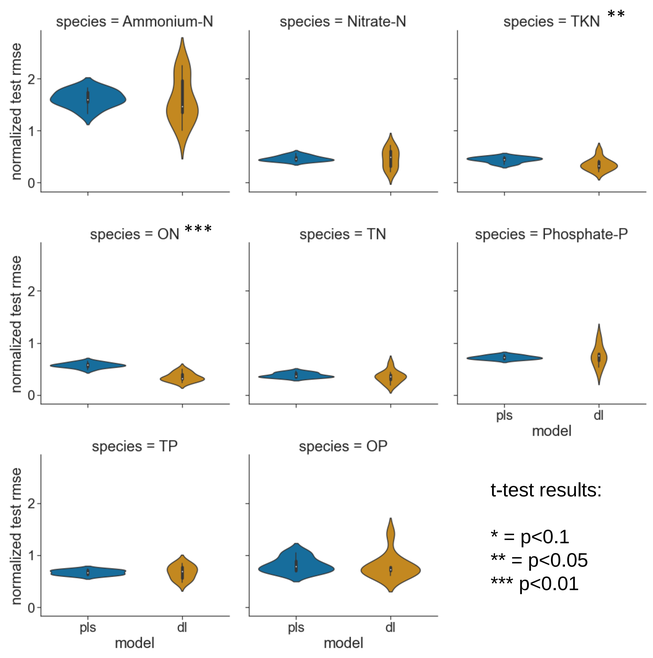

Figure 3. Normalized test root mean square errors for stream samples separated by solute and ML model.

Results - Hydroponics

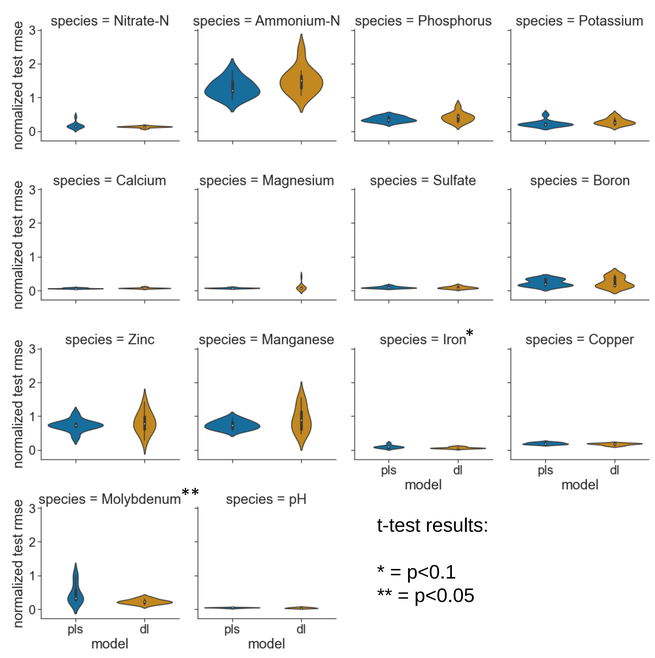

Figure 4. Normalized test root mean square errors for hydroponic samples separated by solute and ML model.

References

[1] Etheridge, J. R., Birgand, F., Osborne, J. A., Osburn, C. L., Burchell, M. R., & Irving, J. (2014). Using in situ ultraviolet-visual spectroscopy to measure nitrogen, carbon, phosphorus, and suspended solids concentrations at a high frequency in a brackish tidal marsh. *Limnology and Oceanography: Methods, 12*(1), 10-22.

[2] Huang, Y., Wang, X., Xiang, W., Wang, T., Otis, C., Sarge, L., ... & Li, B. (2022). Forward-Looking Roadmaps for Long-Term Continuous Water Quality Monitoring: Bottlenecks, Innovations, and Prospects in a Critical Review. *Environmental Science & Technology,* 56(9), 5334-5354.

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