Evaluation of an Automated Micro-Volume *in situ* Spectrometry-based Lab for High Spatial and Temporal Resolution Water Quality Measurements

Bryan Maxwell, François Birgand, Kyle Aveni-Deforge, Brad Smith and Elizabeth Allen

Introduction

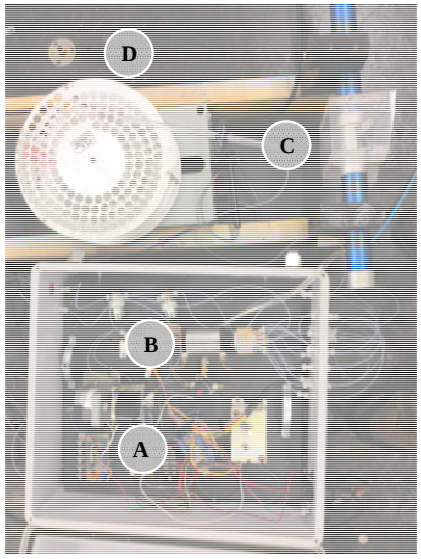
- Data acquisition in environmental sciences is always partial in time and in space
- We often make the hypothesis of spatial and temporal continuity between measurements
- Decisions made from sparse and infrequent data may be risky
- We hypothesize much better decisions could be made from higher spatial and temporal resolution data
- New UV-Vis spectrometer probes make high temporal resolution water quality measurements possible
- But they are expensive, so spatial resolution might suffer unless…

Research Questions

- Can we build a high-frequency WQ automated sampler using UV-vis spectrometry to measure multiple sources of water?
- Can the sampled volume be minimized to expand use for porous media systems?
- What would be the performance of such a system: accuracy, precision, carry over, etc?

System Design Components

- **High sample frequency**: integrated control board provides automated sampling at intervals as low as four minutes.
- **Multi-port intake** : allows system to select which source to sample from by advancing valve with 12 different intakes.
- **Arduino Control Board** : gives high user control to adjust sampling intervals, collection routine, and purge sequences.
- **Triple 3-way valve setup** : provides greater versatility and function; allows water sample to be sent to multiple locations once collected.
- **UV-vis spectrometer** : gives immediate feedback on sample quality and provides accurate results at high sampling frequency.
- **Fraction volume collector** : once samples are tested using UV-vis they can be collected for later lab analysis to validate spectrometer results.
- **Reliable results** : Preliminary lab testing shows efficient purging routine gives low cross contamination between samples (< 1%).



Multiplexor samples uses above Arduino control chip (A) and multi-port actuator (B) to control sample routine and selection. Sample volumes are analyzed by s::can spectrometer (C) in field and collected by fractional volume collector (D) for lab comparison.

System Performance: Method

- 1 - Define best sampling configuration to minimize cross contamination
- Alternating low and high concentrations from separate water sources (fig. 1)
- Low: tap water
- Highs: 3, 7, and 12 mg N/L nitrate solution.

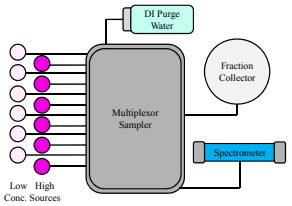


Fig. 1 : General design to define best sampling/rinsing configuration

- 2 - Evaluate performance for best configuration
- Alternating low and high concentrations from single water source (Fig. 2)
- Cross-contamination evaluated in µL residual volume

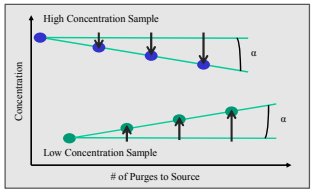
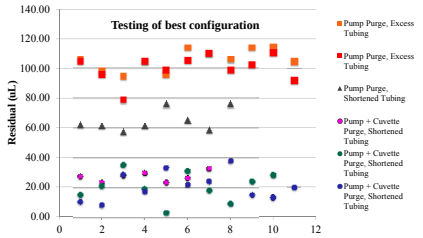
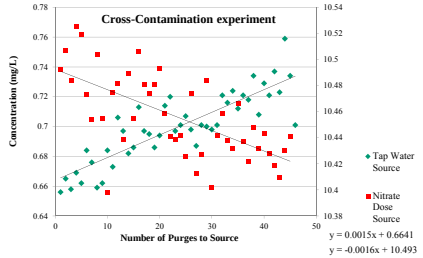


Fig. 2: Drift in concentration of a 500 mL source over successive purges from the Multiplexor back to the source.

System Performance: Results

- Residuals can be minimized to low, consistent vol. (< 40 µL equiv.) using effective purging with DI water and air between samples.
- Testing of source contamination shows low, predictable volumes of residual discharged to the source (< 20 µL equiv.).
- Detectable cross contamination after 1000 purges when alternating 10L solutions of <0.5 mg N/L and 10 mg N/L of nitrate





Potential Applications

- Application to mesocosm studies to provide high resolution data to more accurately determine reaction kinetics.
- High frequency data could provide better picture of nutrient loading to SW following storm events.
- Small sample volume and spatial resolution can provide insight on flow and biogeochemical processes in hyporheic and riparian zones
- Can be used for source testing in hydroponics applications.