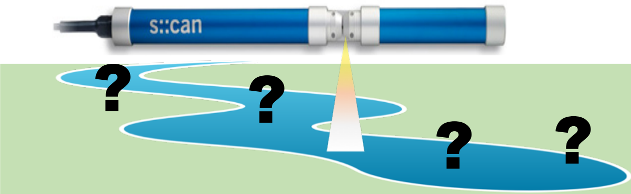
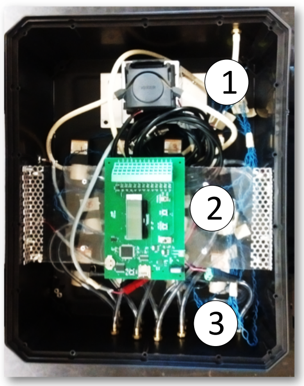
Multi-point sampling methods to improve spatial and temporal resolution of water quality data

Justification and Background

Recent advances in field water quality sensors have opened up the possibility to obtain previously unobtainable information. These sensors provide immense benefits to time frequency of data, but the high expense can limit these instruments to a single location.

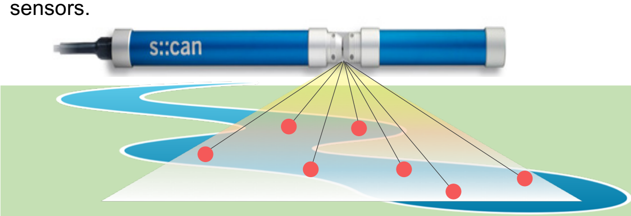


We have developed a system for allowing a single sensor to be in multiple places at once (Birgand et al, 2016). This automated, multi-point sampling (MPS) system uses an onboard peristaltic pump **(1)** controlled by a custom microcontroller **(2)** to selectively sample from multiple inlet lines using a 12-valve manifold **(3).**



Easily deployed for field use, powered by 12 V DC battery, with up to 12 sampling ports.

This system is relatively inexpensive to build, easily customized, and highly portable for field use. It can be integrated into a wide variety of sensors including spectrophotometers, sondes, and flow-through analyzers. This system provides continuous water quality data at multiple locations at a fraction of the cost of as many WQ sensors.



Previous Applications & Results

In-situ mesocosms were created by inserting open-ended barrels into the stream sediment of a coastal NC stream. Five mesocosms were sampled every 30 min. for 24 hours using the multi-point sampler integrated with an s::can spectrophotometer. Downward flux of nitrate was measured in two different sediment types at three stations over nine months. The stream showed high seasonal variability with unexpected trends (Fig. 1) and high spatial variability with flux rates varying by 3x in mesocosms only several feet apart (Fig. 2)

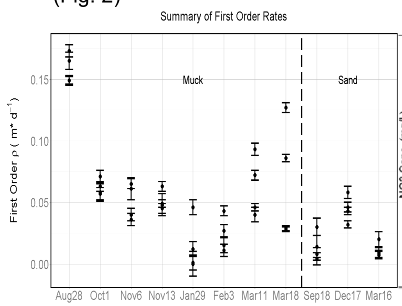


Fig. 1 – First order nitrate removal rates over time in Muck and Sand sediments

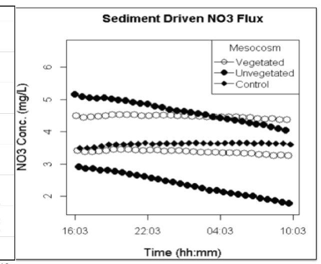
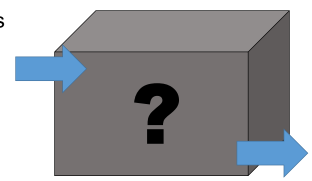


Fig. 2 – Nitrate conc. over 24 hours in vegetat and unvegetated mesocosms.

Many ecological engineering tools often operate as "black box" systems. Integrative methods measure composite performance without understanding internal hydraulic/biological inefficiencies. We used the MPS to monitor well networks in a woodchip bioreactor to monitor porewater nitrate concentrations under continuous flow and nitrate slug injections. This method can provide heat maps (Fig 3) to show local treatment inefficiencies.



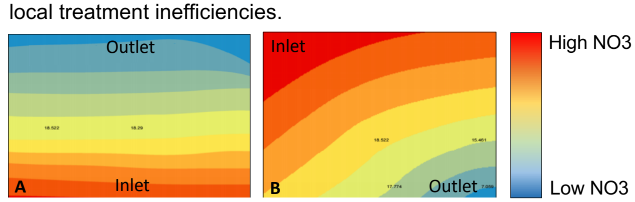


Fig. 3 – Nitrate heat maps in porewater wells of a woodchip bioreactor from top view (A) and side view (B).

Floating Treatment Wetland Retrofit

Floating treatment wetlands (FTW) have the potential to improve water quality in water bodies receiving runoff. The extent of this benefit is still unclear, as well as the relationship between treatment efficiency and % coverage of the pond by FTW. Current flow-proportional sampling that captures one data point per storm also limit the ability to confidently detect improvements in treatment efficiency. To address this problem, we have divided an NCSU stormwater pond into two sections using an impermeable liner (Fig. 4). FTW modules have been installed on one side of this barrier. Over the next year the MPS will capture water quality dynamics before, during, and after storms to determine differences in water quality between the two treatments.

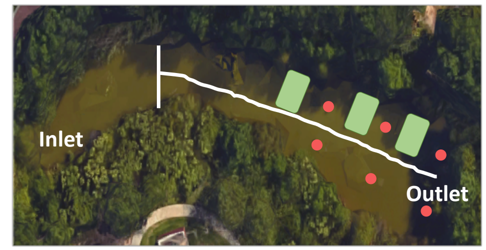


Fig. 4 – Top view of stormwater pond at NCSU campus. One side of the pond has FTW modules arranged perpendicular to the flow path at three locations along the pond. MPS coupled with spectrophotometer will allow continuous monitoring of water quality at three locations within each treatment. FTW modules are placed perpendicular to flow and spanning the channel width to improve treatment efficiency.

Continuous water quality monitoring within both treatments will show never before seen nutrient dynamics during storm events, as well as provide greater confidence in differences between both treatments. High spatial and temporal resolution will illustrate spatial distribution of nutrients and kinetics of *in-situ* removal rates.

The MPS technology can reveal previously unseen insights into spatial and temporal water quality dynamics and increase the confidence in conclusions when comparing different treatments.

Contributing Authors : Bryan Maxwell, Dr. Francois Birgand, Danielle Winter, Sam Garvey, Caleb Ray, Dr. Troy Gilmore

References : "First report of a novel multiplexer pumping system coupled to a water quality probe to collect high temporal frequency in situ water chemistry measurements at multiple sites." *Limnology and Oceanography*. 2016