Biotic and abiotic factors that may influence denitrification potential

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Background

Denitrification is a bacterial process that is a part of the nitrogen cycle and occurs in anoxic environments, such as wetlands[4]. In this process, nitrate (NO_3) is converted to nitrogen gas (N_2O and then N_2) and is released into the atmosphere. Excess nitrogen in the environment decreases water quality, poses health risks[1], and causes adverse effects on ecosystems[5]. Available nitrogen has increased because of anthropogenic sources such as nitrogen fertilizers, stormwater runoff, and industrial waste[5]. Understanding what promotes wetland denitrification, may enable us to facilitate higher rates, mitigating some of the increased inputs[6,7].

Unfortunately, denitrification is a difficult process to accurately and easily measure and the factors that regulate the process are not clearly understood[2,3]. In order to target denitrification in wetlands we need to understand which conditions are correlated with denitrification potential.

I measured levels of ammonia, phosphorous, and nitrate, biomass of plant material, soil moisture, and nitrogen isotope ratios in plant shoots and soil to see if any of these factors are strongly correlated to denitrification potential.

I conducted my experiment in 16 mesocosms at the University of Wisconsin - Madison. Because of the controlled nature of my sample sites, they may show less volatility than natural wetlands, which could help to produce clearer results than a field study.

Figure 1 – Mesocosms at the University of Wisconsin – Madison (Photo: botany.wisc.edu)

Methods

2M KCl solution was used to extract nutrients from soil samples and then analyzed using the SEAL AQ2+ Auto Analyzer (Figure 2)

Denitrification Enzyme Activity Assay was used to find a denitrification potential for each sample (Figure 3). This is done through a laboratory procedure in which the samples are flushed with helium, and denitrification is inhibited with acetylene so it stops at the step which produces N_2O. N_2O is then collected to measure denitrification potential so the issues with measuring N_2 are not present.

An Elemental Analyzer – Isotopic Ratio Mass Spectrometer will be used to find nitrogen isotope ratios on plant and soil samples that were dried and powdered.

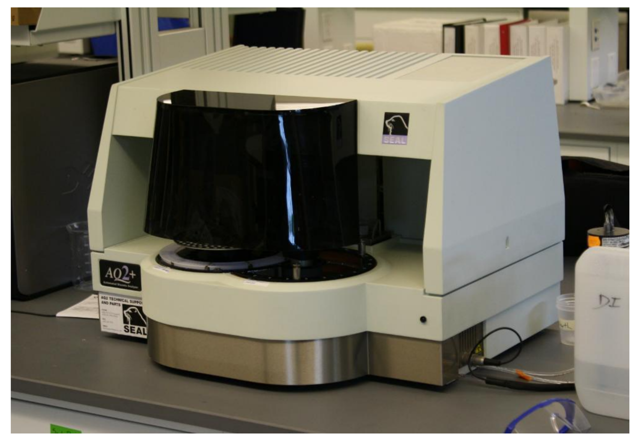


Figure 2 – SEAL AQ2+ Auto Analyzer

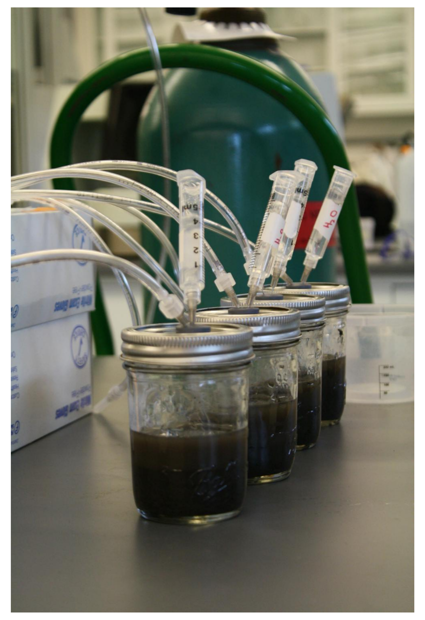


Figure 3 – Helium flushing during DEA

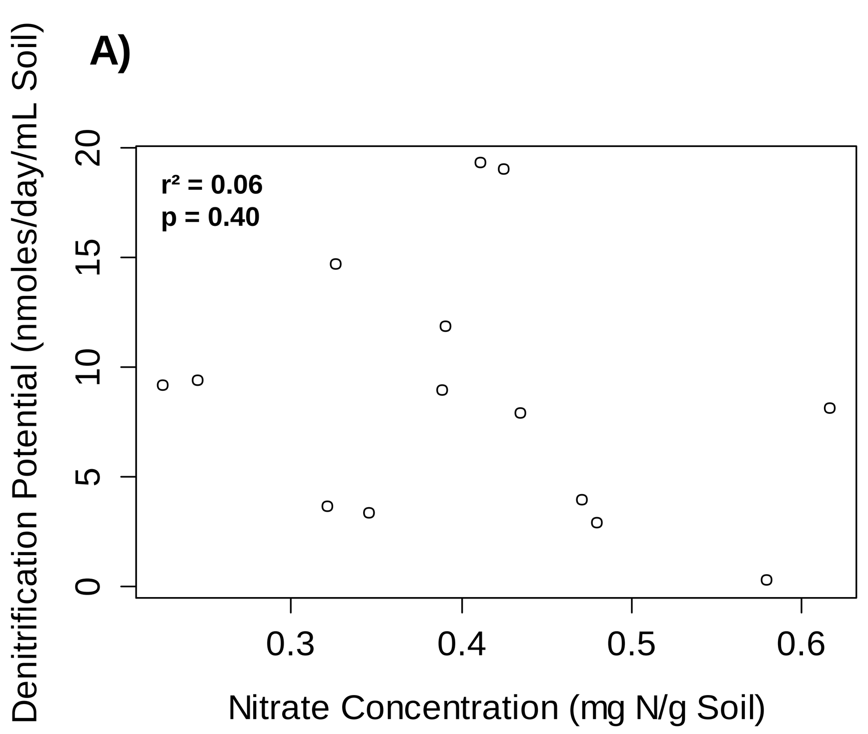
Hypotheses

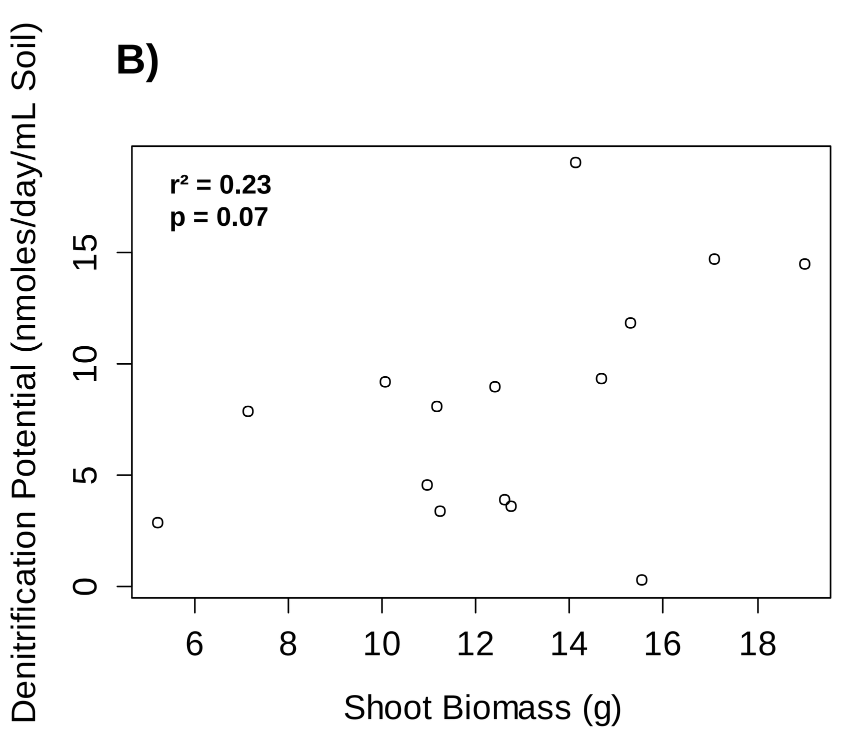
Higher nutrient levels will lead to higher denitrification potential. Increased resource availability will promote more active denitrification potential.

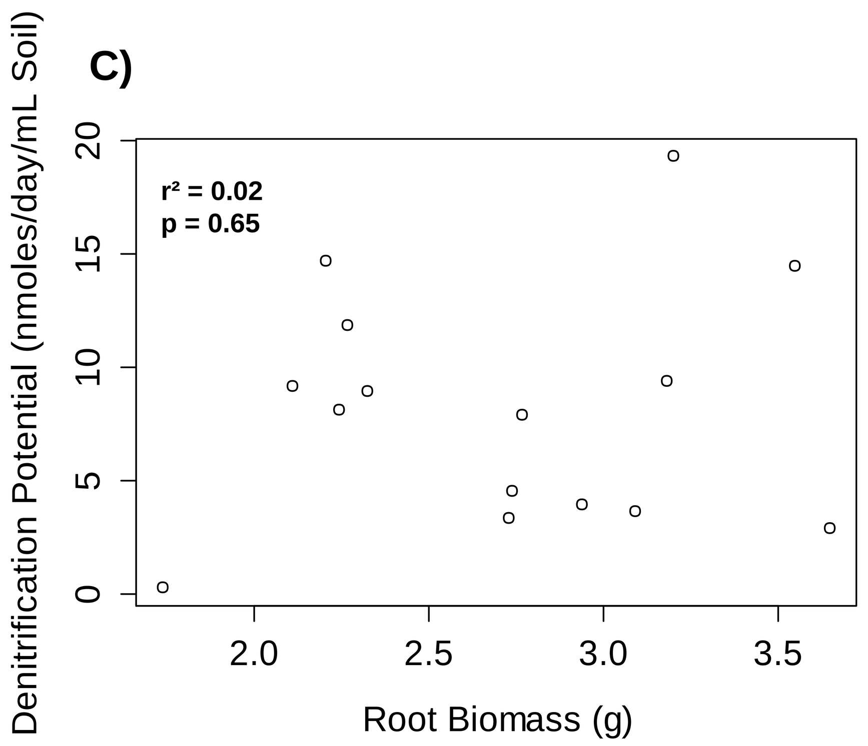
Higher plant biomass will lead to lower denitrification potential. Increased plant biomass reduces the availability of resources to bacteria.

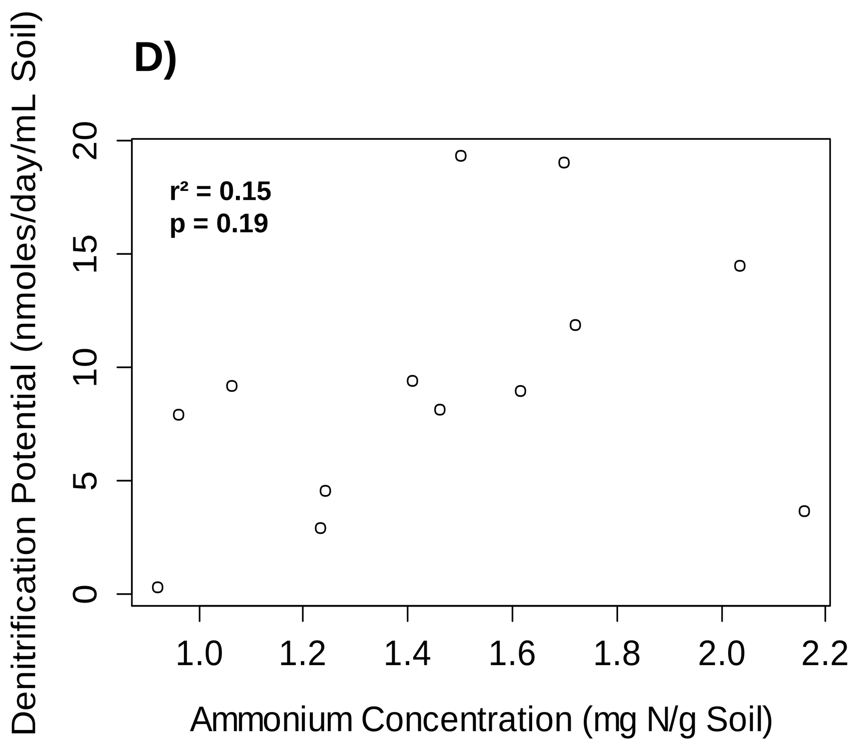
Higher denitrification potential will lead to higher ∂15N in roots, shoots, and soil. Lighter isotopes are used first because they requires less energy, leaving heavier isotopes behind - a process called fractionation.

Results









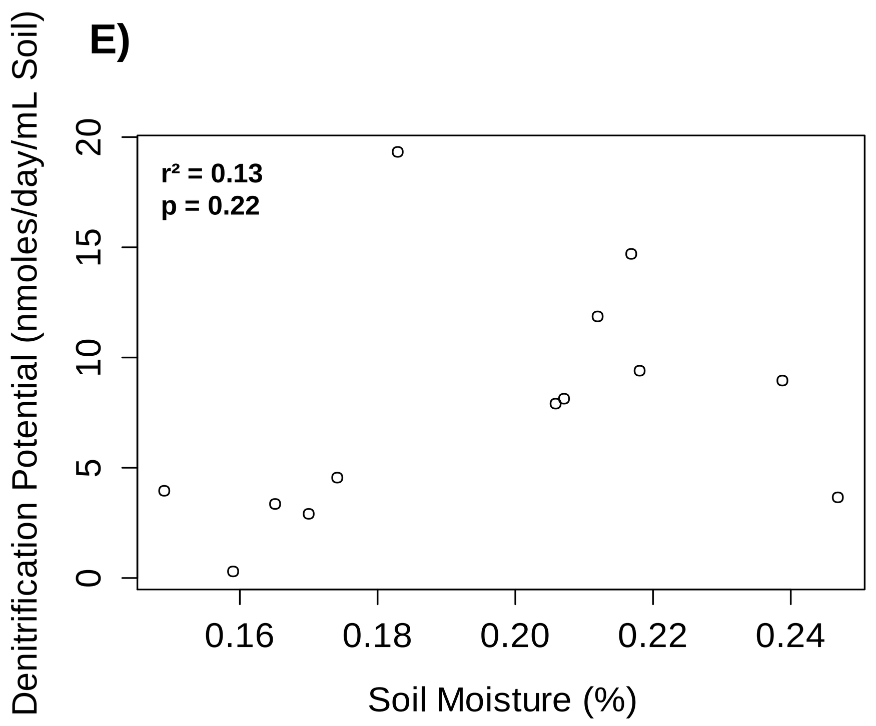


Figure 4 – Linear regression of A) nitrate concentration, B) shoot biomass, C) root biomass, D) ammonium concentration, E) soil moisture vs. denitrification potential with ANOVA analysis to return r² and p values

Results

None of the factors (nitrate concentration, ammonium concentration, root biomass, shoot biomass, and soil moisture) measured in this experiment were proven to be significant indicators of denitrification potential at the $p<0.05$ level (Figure 4).

Conclusions

Because none of the relationships were significant, this study did not show that any of the measured factors have an influence on denitrification potential.

Results are pending for the isotope data so a relationship between ∂15N in roots, shoots, and soil vs. denitrification potential has yet to be analyzed.

While no relationships were proven to be significant, some still held a weak correlation. This could suggest that significant results could be found were this experiment able to use more than 16 test sites. If the remaining 48 mesocosms had also been tested, these relationships may have been significant. It is also possible that the results may have been different had this experiment been conducted in a natural wetland as opposed to a collection of homogenous mesocosms.

Acknowledgements

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