Chemodenitrification to N_2: The Dark Side of the Nitrogen Cycle

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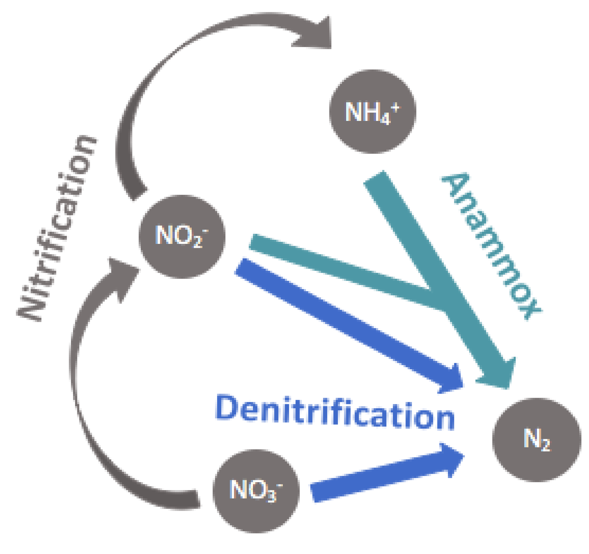
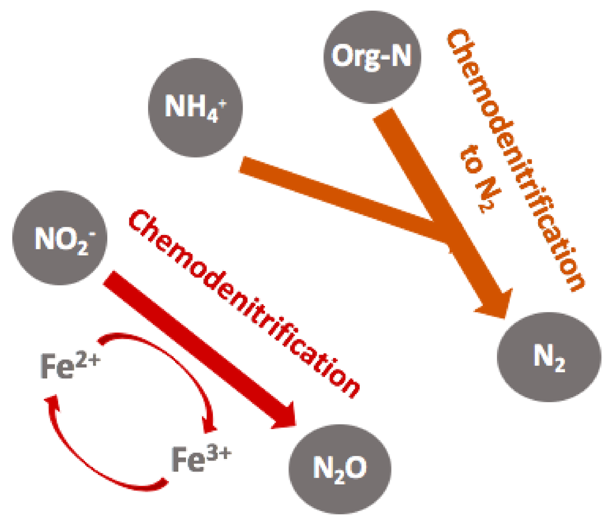
Denitrification and anammox are major enzymatic processes that effectively remove reactive nitrogen (N) in the environment by transforming it to inert dinitrogen (N_2) gas. Chemodenitrification is another N removal pathway in which nitrite (NO_2^-) reacts abiotically with organic N or ammonium (NH_4^+) to produce N_2. This reaction has been observed previously and chemodenitrification producing N_2O has been recognized in acidic soils, however, chemodenitrification to N_2 may also occur providing a new avenue of N removal [1,2]. This is an understudied pathway that calls into question assumptions in current models of the N cycle.

Research Objectives

1) Detect and quantify chemodenitrification to N_2 as an abiotic N removal pathway
2) Determine chemical characteristics affecting abiotic N_2 production
3) Evaluate the importance of abiotic N_2 production in the natural environment
4) Explore a pathway coupling biotic and abiotic processes of nitrogen removal

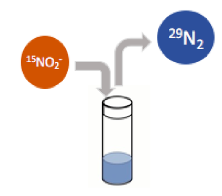


Biotic N Rmoval Pathways



Abiotic N Removal Pathways

Methods



1. Solution Incubations
Sterile phosphate buffer pH adjusted amended with $^{15}NO_2^-$ and ^{14}N substrates

2. Sterile Soil/Sediment Incubations
Soils and sediments of varying pH collected and sterilized for anoxic incubation with $^{15}NO_2^-$

3. Abiotic – Biotic Coupling Incubation
Live and deal soils from an acid mine drainage site incubated with $^{15}NO_3^-$ and $^{15}NO_2^-$

$^{29,30}N_2$ analysis by Isotope Ratio Mass Spectrometry

RESULTS:

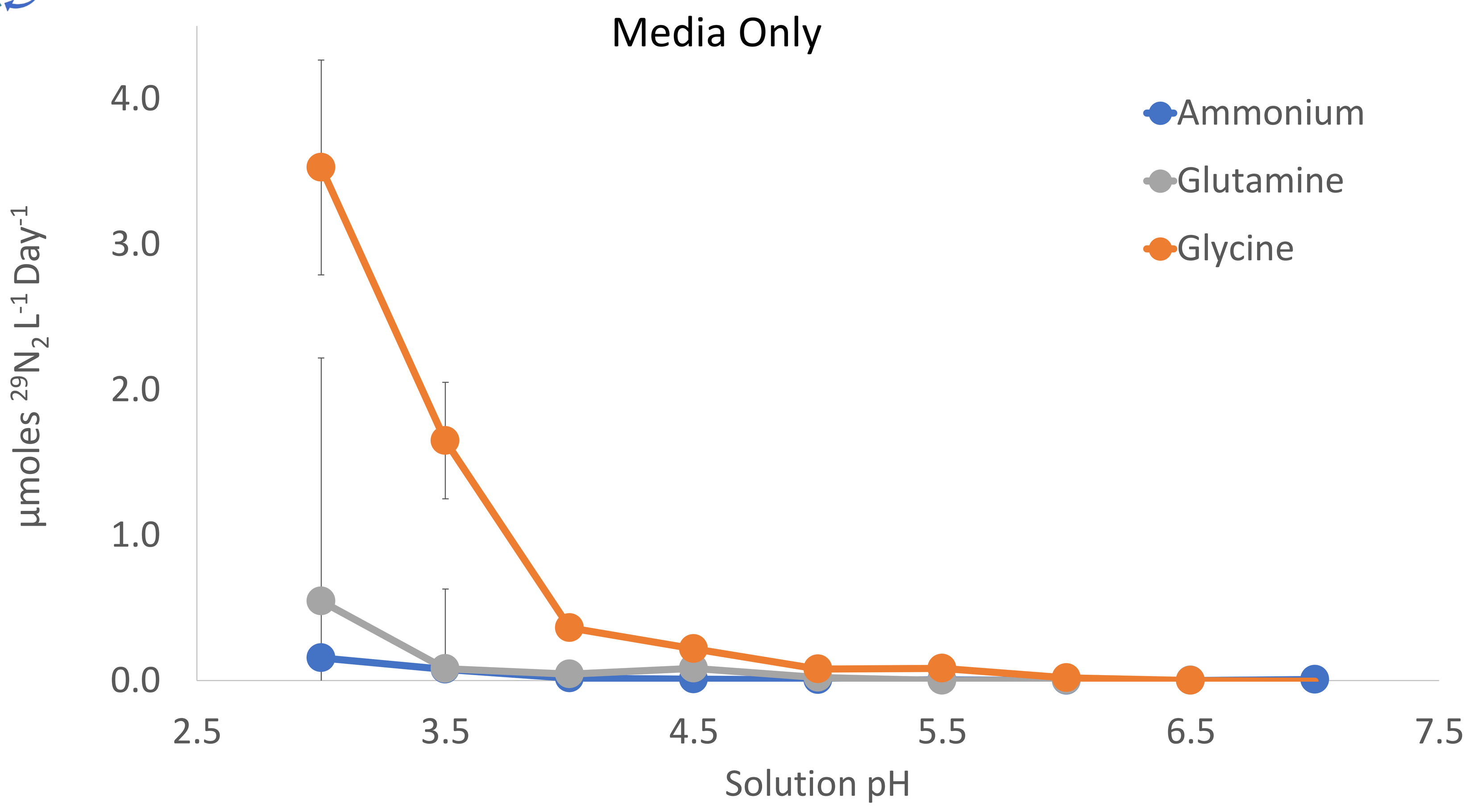


Figure 1. $^{29}N_2$ production from $^{15}NO_2^-$ and ^{14}N-partners along a pH gradient with substrate concentrations of 1mM. The highest reactivity was observed at the lowest pH.

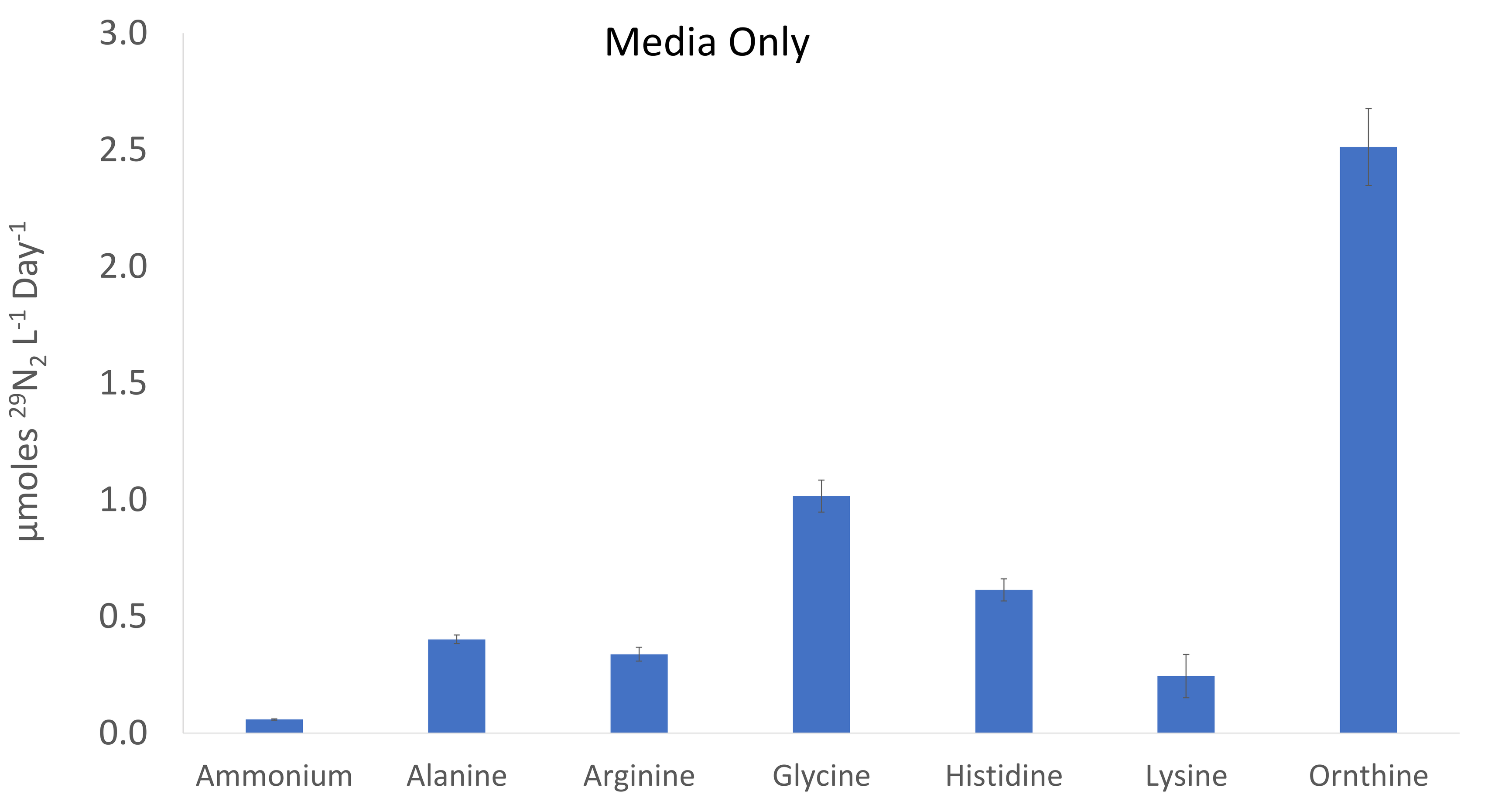


Figure 2. $^{29}N_2$ production at pH 5 from $^{15}NO_2^-$ and various ^{14}N-partner amino acids found in soils with substrate concentrations of 5mM[3]. Differential reactivity indicates that some organic N is more reactive for abiotic N_2 production.

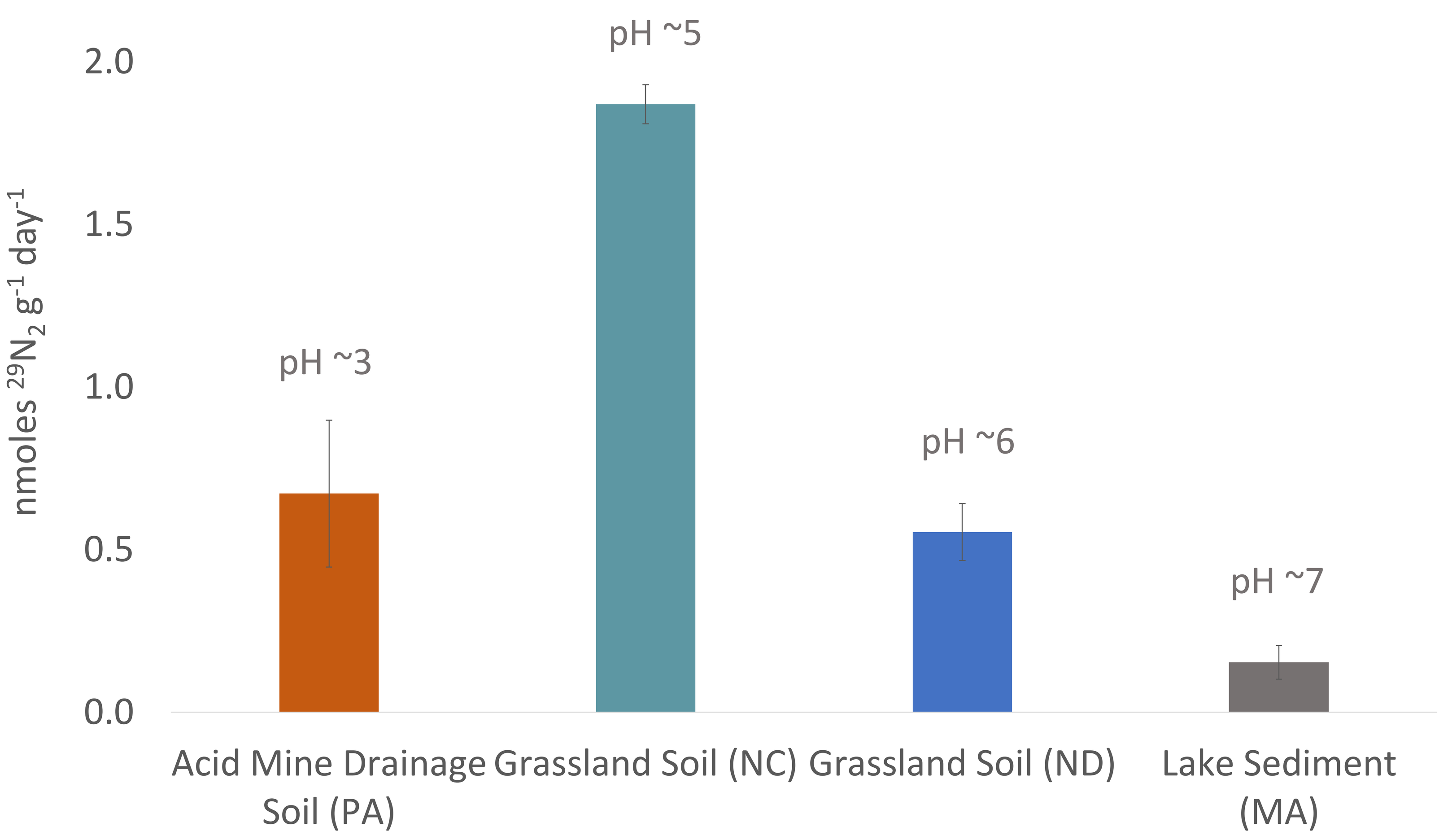


Figure 3. $^{29}N_2$ production from $^{15}NO_2^-$ amended soil samples of varying pH. Despite pH being lower in acid mine drainage soils the highest activity was observed in the NC grassland soils.

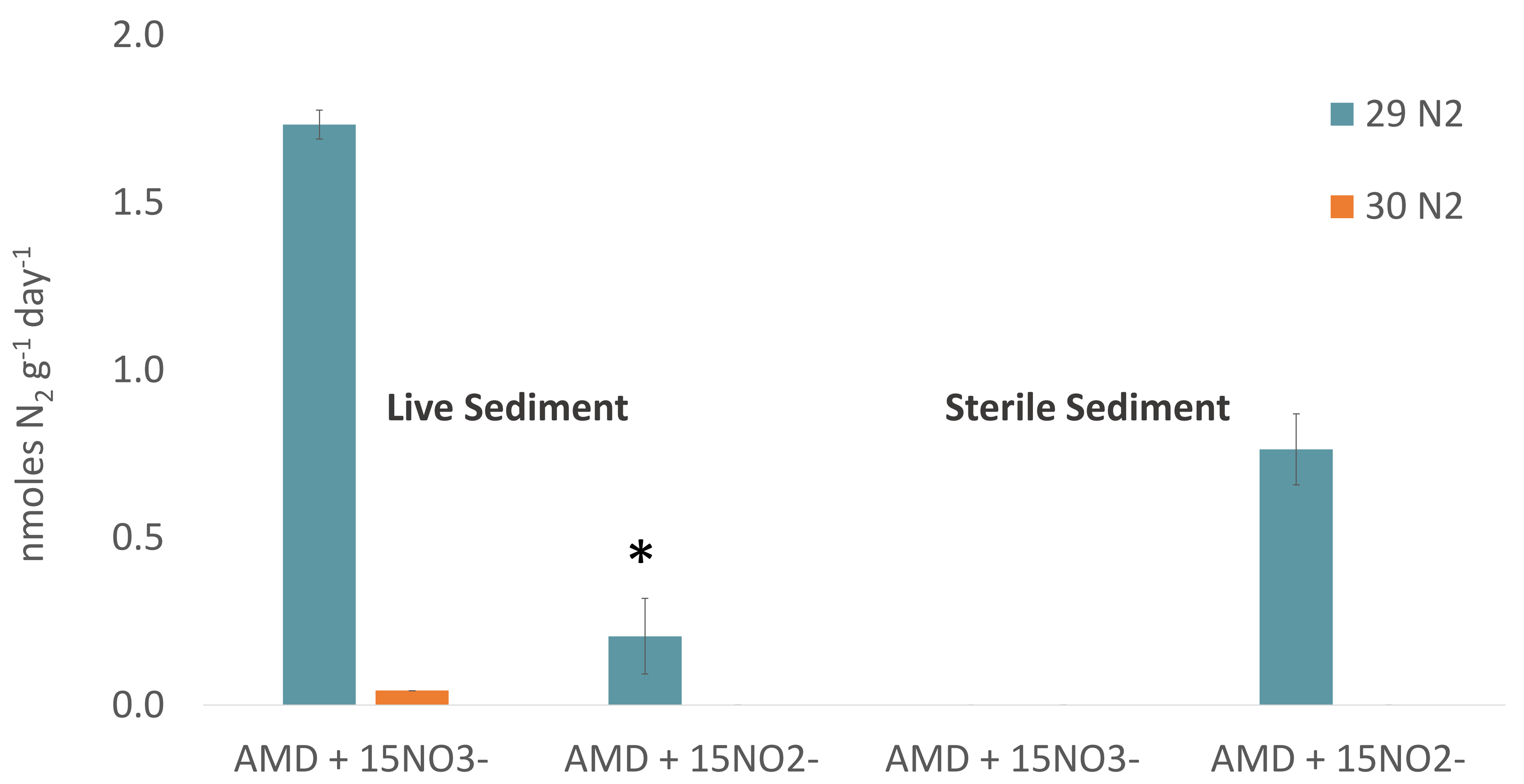


Figure 4. Comparison of denitrification ($^{30}N_2$) and chemodenitrification ($^{29}N_2$) in live and dead soils of acid mine drainage. Both $^{29}N_2$ and 30N2 production was observed in the live soils with $^{15}NO_3^-$ while $^{29}N_2$ only was detected in the dead soils. * indicates abiotic $^{29}N_2$ production in live soil samples.

CONCLUSIONS:

- Chemodenitrification to N_2 was detected in acidic solutions and all the soils/sediments tested.
- Both pH and organic content were identified as important characteristics affecting abiotic N_2 production.
- Abiotic N_2 production rate was highest in grassland soils of North Carolina, which may be associated with reactive organic N.
- A potential coupling of biotic reduction NO_3^- to NO_2^- and abiotic N_2 production was observed in acid mine drainage soils.

References:

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