Chemical and Hydrologic Connectivity of Surface and Porewater in an Urban Accidental Wetland, with Implications for Nitrogen Removal

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Background

Unmanaged, accidental wetlands have developed in the Salt River channel near downtown Phoenix, Arizona. The ecosystem is fed by nutrient-rich water supplied by stormwater drains (Fig. 1)

In this study, we investigated the biogeochemistry of two vegetated patches and one unvegetated patch (Fig. 2). Our objective was to evaluate potential for nitrate (NO_3^-) transformation and removal.

Examples of the patches used in this study at 7[Th] Avenue site. The 7[th] Avenue bridge is pictured on the left.

Figure 2.

Expectations

We predicted that surface water and porewater would be hydrologically connected in the wetlands, but that the biogeochemical environments would differ between compartments (surface and porewater) and among patch types, resulting in different potential for nitrate removal.

Nutrient-rich water is delivered to the surface water of the wetlands via stormwater drains. We hypothesize that nitrate in the surface water diffuses to the porewater, where low oxygen and high dissolved organic carbon concentrations promote microbially mediated denitrification and dissimilatory nitrate reduction to ammonium (DNRA; Fig. 3).

Hypothesized movement and transformation of nitrate through the surface and porewater.

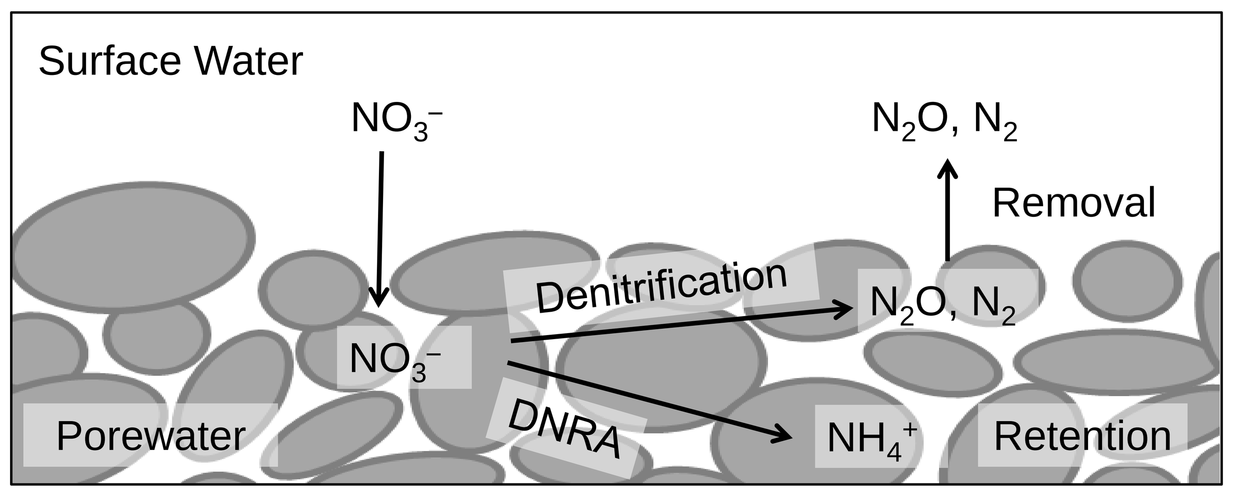
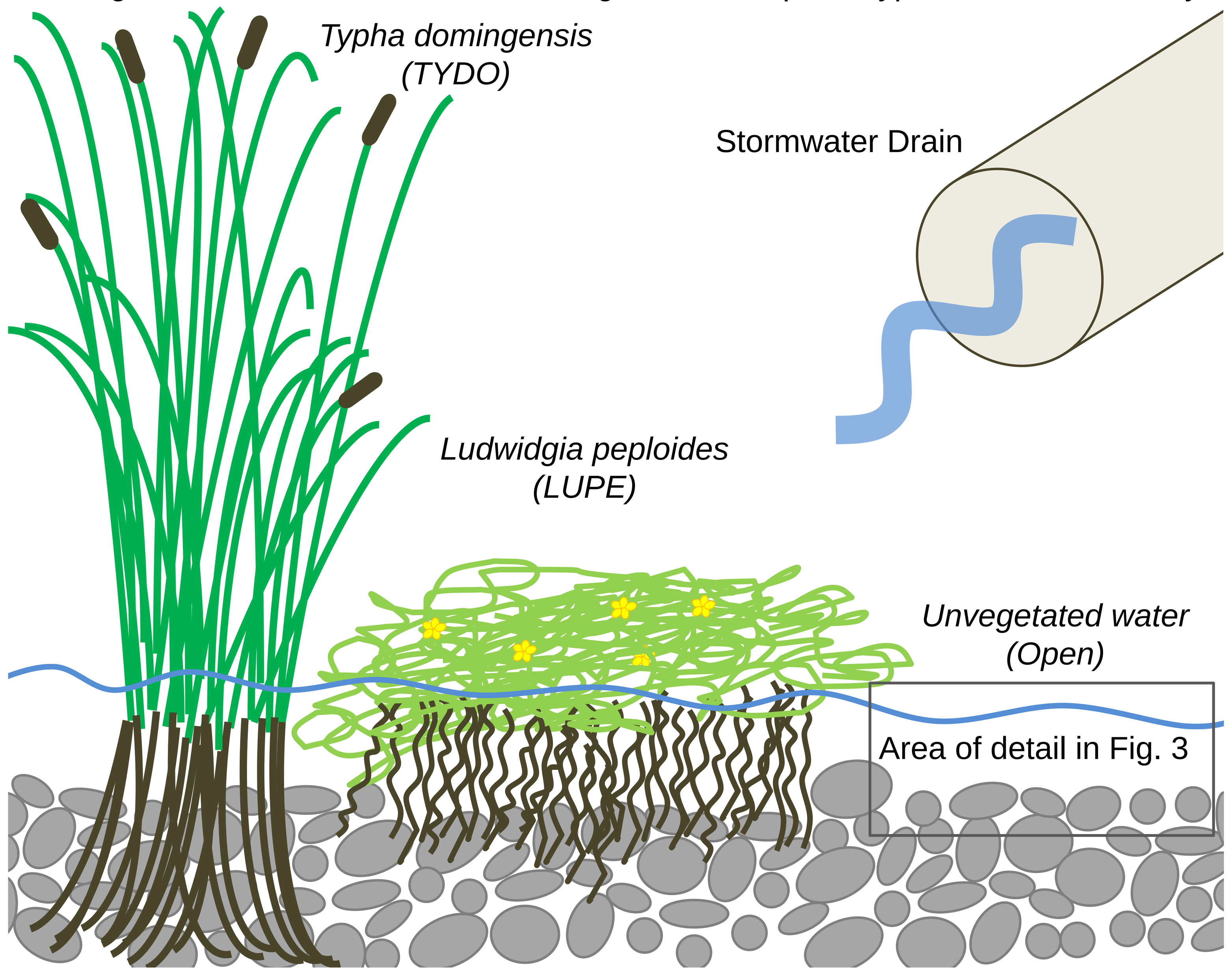


Figure 3.

Figure 1. Schematic of wetland configuration and patch types used in this study.



Field Water Chemistry Investigation

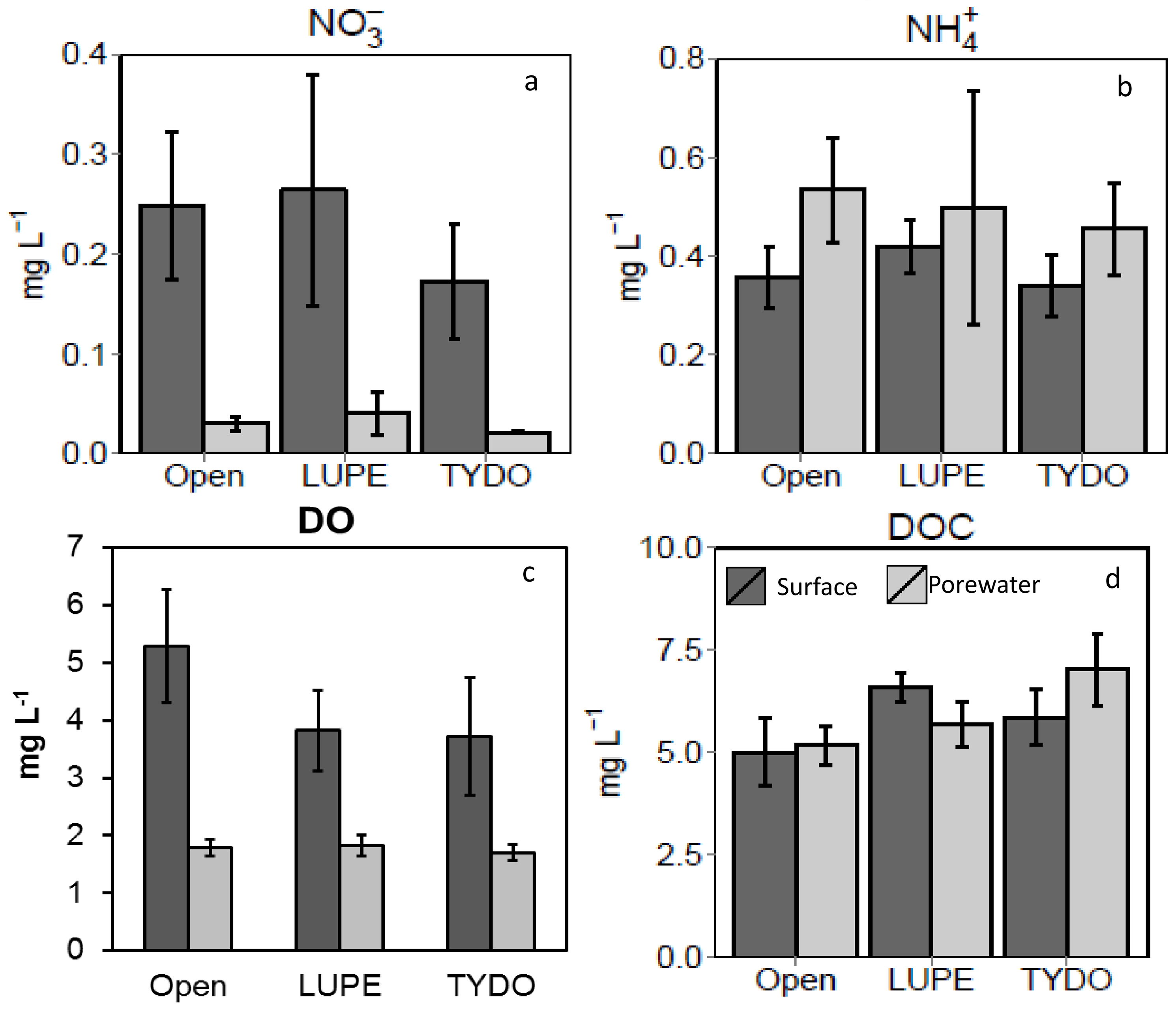


Figure 4. Mean ± 1 SE.

The Salt River wetlands have chemical conditions that indicate presence of microbial nitrate reduction including lower nitrate concentration in the porewater, low DO, and high DOC (Fig. 4).

Only DOC was significantly higher in the vegetated patches compared to open patches (Fig. 5).

Model: Concentration = β_P Patch + β_W Water Compartment + β_S Site

Vegetated vs. Open Patches

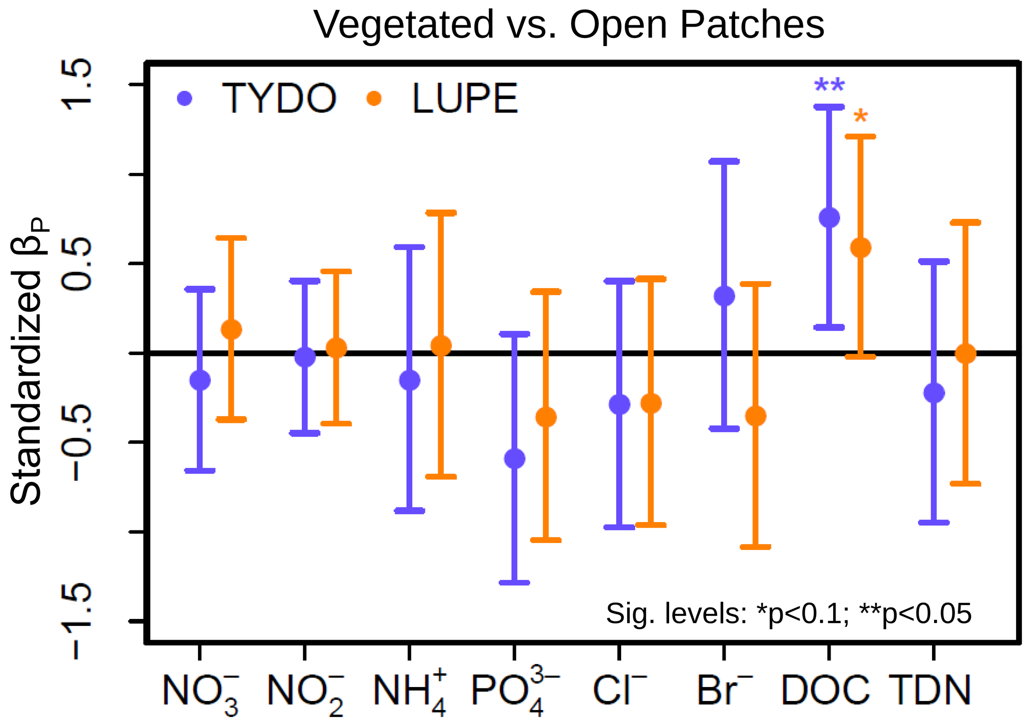


Figure 5. Mean ± 1 SE. Regression coefficient ± 95% CI

Wetland Soil Incubation Experiment

Question: Does the nitrate concentration moderate the relative proportion of denitrification and DNRA in the Salt River Wetlands?

Nitrate concentrations in the surface water increase during stormflow events. If nitrate concentrations moderate the proportion of denitrification and DNRA then the wetlands could support more denitrification during storm flows while retaining reactive nitrogen during low flows via DNRA.

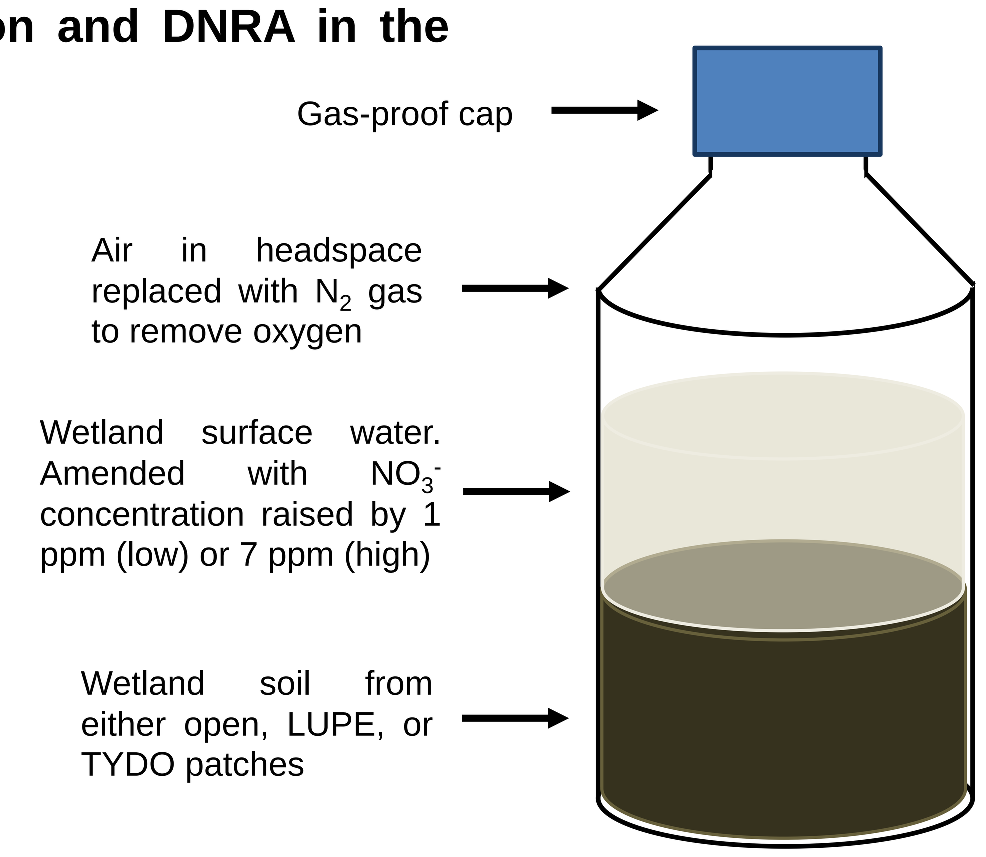


Figure 6. Microcosm experimental design

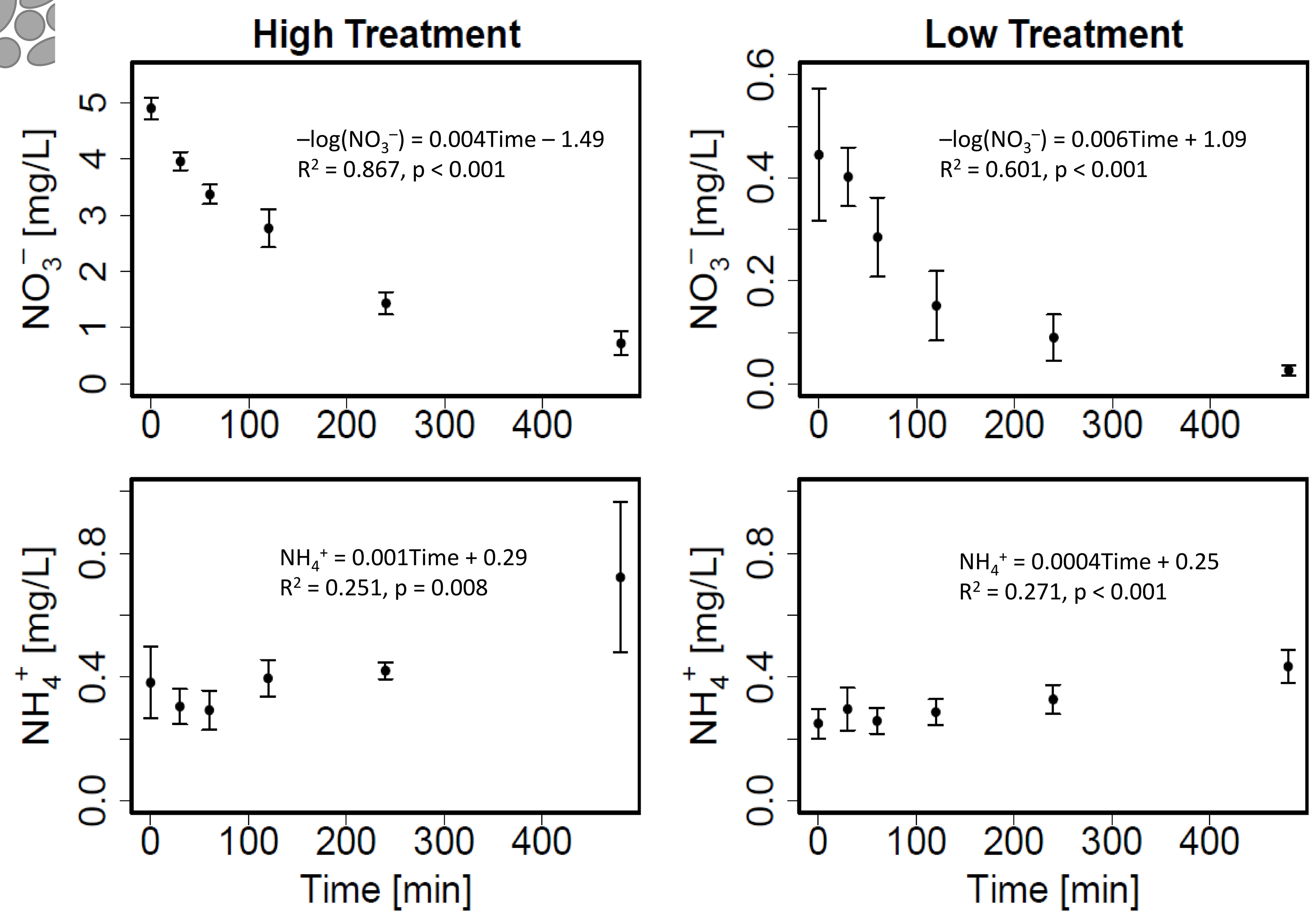


Figure 7. Mean microcosm NO_3^- and NH_4^+ in the high and low amended microcosms ± 1 SE.

The Salt River wetland soils have the ability to rapidly consume and transform nitrate.

Assuming all changes in ammonium concentration are due to DNRA, then DNRA accounted for 8% and 44% of the nitrate removal in the high and low treatments, respectively, over the 8 hour incubation period.

The increase in the ammonium concentration relative to the starting concentration was more similar among the two treatments at 89% and 74%, respectively. This suggests that the rate of DNRA may be insensitive to nitrate supply.

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