Denitrification and Microbial Processes in Dredge Material Created Wetlands

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Introduction

- Coastal wetlands provide many important ecosystem services, including improvement of water quality via nitrate removal (Fig. 1)
- Wetland creation is one strategy to replace lost wetland areas using repurposed dredged mineral sediments.
- Research is limited on the long-term success of biogeochemical cycling in created wetlands.
- Vegetation and microbial communities have been found to recover faster than the accumulation of organic matter.

Objectives & Hypothesis

- Determine the impact of dredged sediment placement on N cycling in marsh soils
- Compare denitrification rates in created marshes to natural ones to determine the effectiveness of this restoration strategy
- Hypothesized that denitrification rates will be lower in the created marshes compared with the natural site because the mineral composition of the parent sediment typically supports less microbial biomass

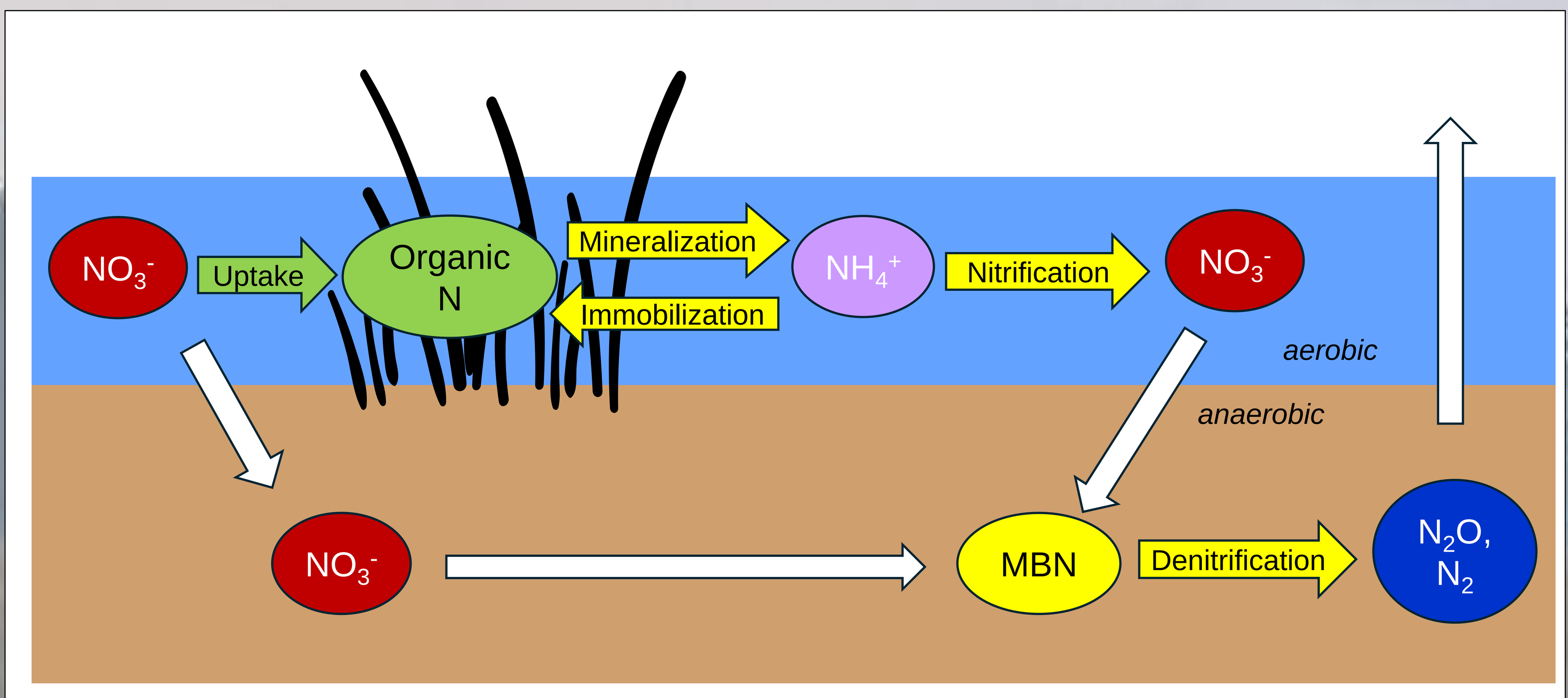

Figure 1: N cycling in coastal wetland soils.

Study Area

- Big Branch Marsh National Wildlife Refuge 2018 marsh creation project (PO-104) used dredged sediment from Lake Pontchartrain estuary (Fig. 3).
- Sampled confined and unconfined created marshes as well as natural marsh control (Fig. 2).

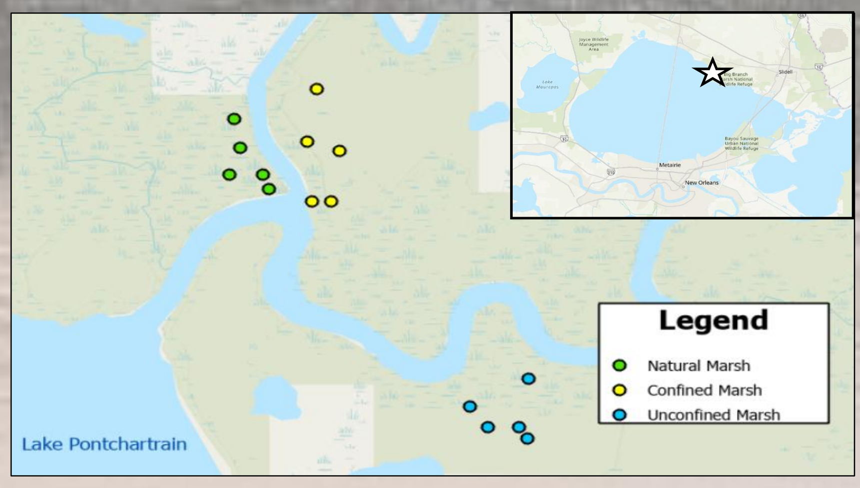

Figure 2: Study area (ArcGIS).

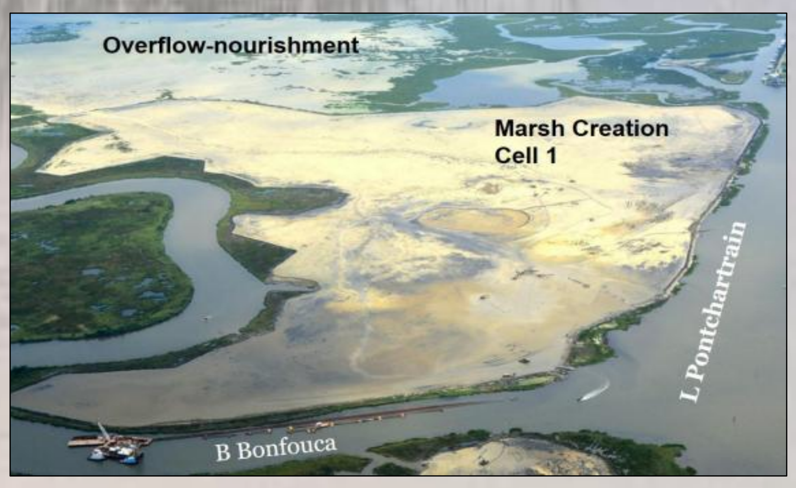

Figure 3: Marsh creation area being filled with dredged material (CWPPRA).

Methods

- Five 10 cm cores taken from each marsh type for analysis of soil properties (Fig. 4).
- Intact cores spiked with 2 mg L^{-1} NO_3-N and incubated for seven days under aerobic conditions for denitrification experiment (Fig. 9).
- Samples analyzed on a Seal AQ-300 for NO_x (USEPA, 1993; Fig. 5).
- Denitrification rates determined from the slopes of N concentration over time (Fig. 8).

Figure 4: Sample collection

Figure 5: Colorimetric analyzer for NO_3 determinations (AQ-300).

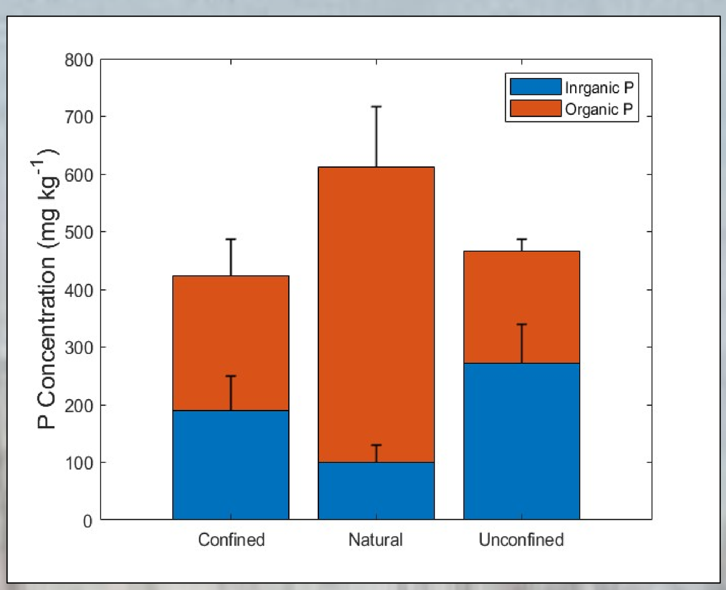

Figure 6: Mean $\pm$ std soil organic and inorganic components of TP.

Results

- No significant difference in denitrification rate between marsh types (Fig. 8).
- Natural marsh denitrification rates had a higher variability compared to the created marsh sites.
- Elevation was positively correlated with bulk density (r = 0.55) and negatively correlated with moisture content (r = -0.49)
- Extractable NH_4 and total P higher in natural marsh (Table 1).
- Greater proportion of organic P in natural marsh than created marshes (Fig. 6).

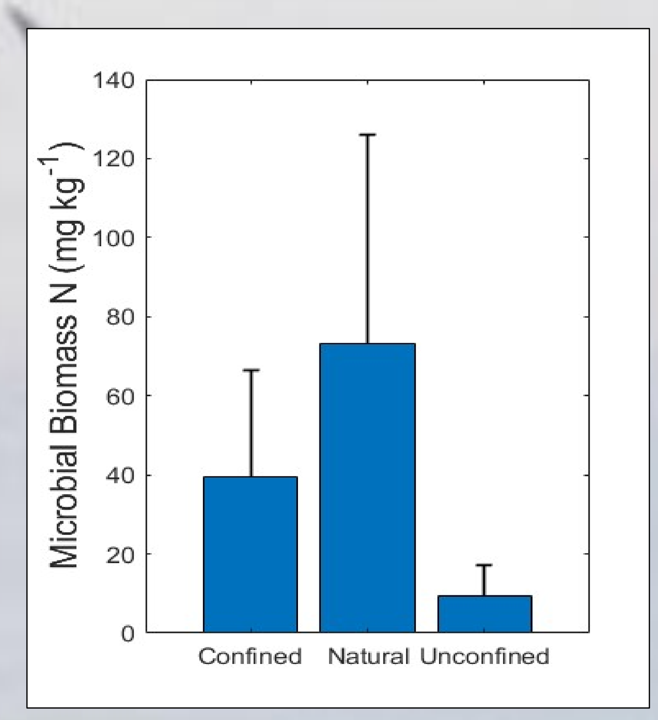

Figure 7: Mean $\pm$ std MBN in the 0-5 cm interval.

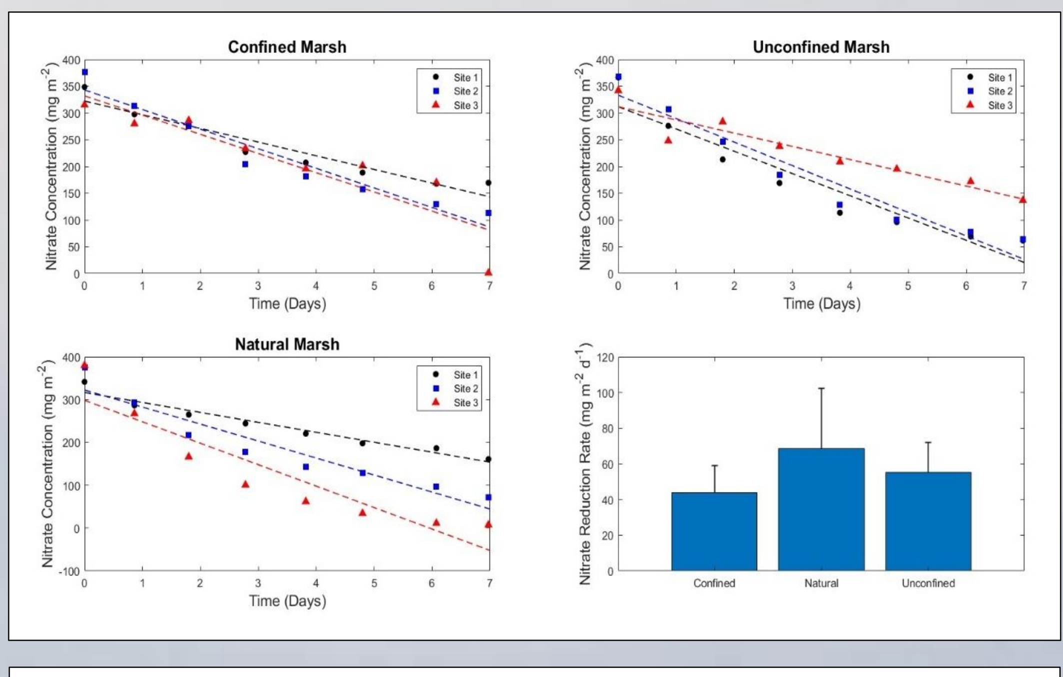

Figure 8: Change in nitrate concentrations over time for replicates of each marsh type along with mean ± 1 standard deviation denitrification rate.

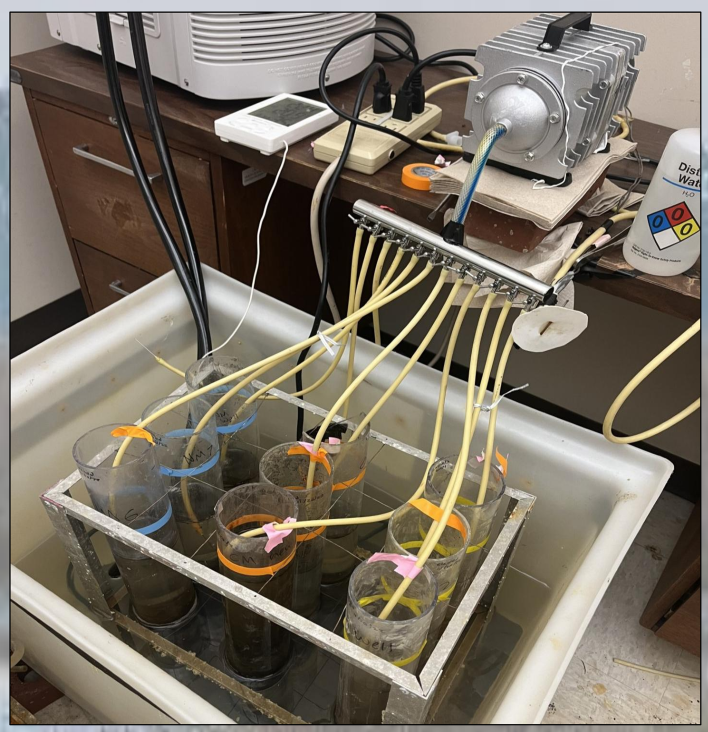

Figure 9: Core incubation bath

Table 1: Mean $\pm$ std. soil properties for the 0-5 cm depth intervals from each marsh type.

Soil Property	Confined Marsh	Unconfined Marsh	Natural Marsh
Denit. Rate (mg m^{-2} d^{-1})	43.7 ± 15.2^a	53.9 ± 19.0^a	65.0±39.6^a
Bulk Density (g cm^{-3})	0.48±0.29^{a,b}	0.37 ± 0.03^a	0.18±0.06^b
Organic Matter (%)	21.6 ± 13.6^a	11.1 ± 2.46^b	37.6 ± 14.6^a
Total C (g kg^{-1})	106 ± 70.8^a	43.3 ± 13.7^b	176 ± 63.3^a
Total N (g kg^{-1})	6.01 ± 3.42^a	3.06 ± 0.39^b	10.26 ± 3.10^a
Ext NH_4 (mg kg^{-1})	47.1 ± 64.6^a	74.4 ± 27.1^a	163 ± 78.5^b

Discussion

- Denitrification rate was positively correlated with organic matter content, moisture content, and total P.
- Denitrification is limited more by NO_3^- concentrations than C because only 5 mols of C are required to reduce 4 mols of N and C is found in much greater concentrations in the environment.
- NO_3^- concentration depends on diffusion into the soil, which is affected by physical characteristics of the soil (Fig. 10).
- Microbial biomass also influences denitrification rate (Fig. 7).

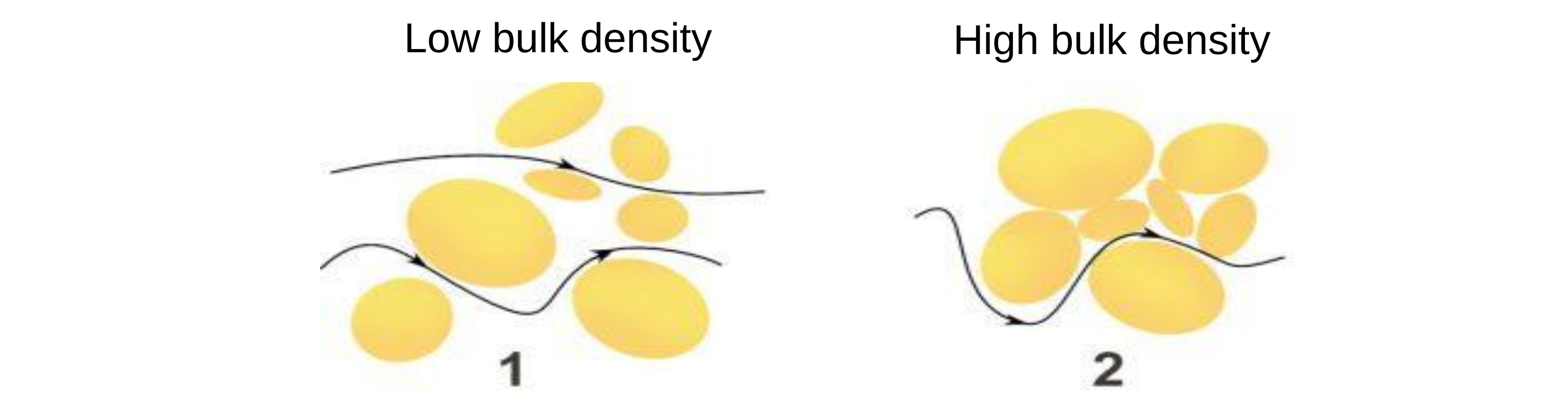

Figure 10: Bulk density and porosity affect the diffusion pathlength, which can limit NO_3^- concentrations in the soil (Encyclopedia of the Environment).

Conclusions

- Results suggest that the water quality function of newly created marshes is quick to develop despite lower soil organic content.
- Several important indicators of biogeochemical cycling (organic matter, microbial biomass, denitrification rate) were statistically similar between the natural and confined marshes.
- Dredge material created marshes are equally as effective at nitrate reduction as their natural counterparts, making marsh creation a viable restoration strategy for improving coastal water quality.

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