FATE OF EVERGLADES DISSOLVED ORGANIC MATTER IN FLORIDA BAY

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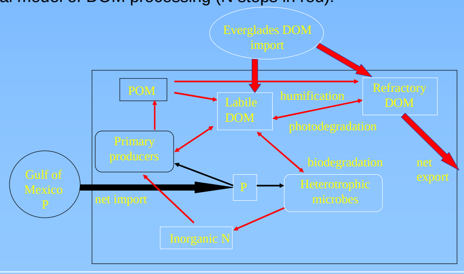
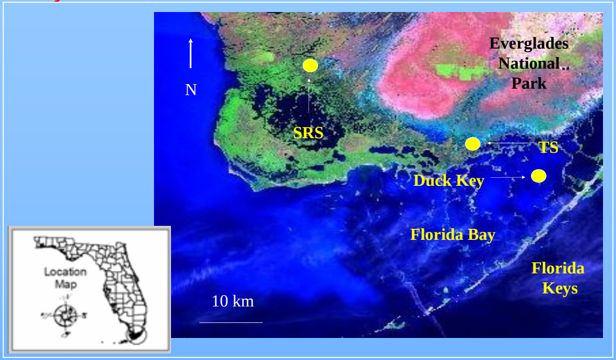
Introduction

Hydrologic restoration of the Everglades system will result in increased fresh water flow toward Florida Bay. Nutrients, especially dissolved organic nitrogen associated with this increased flow, may impact the Florida Bay ecosystem. Little is known of the fate and effects of Everglades dissolved organic matter (DOM) in Florida Bay. This is a key uncertainty regarding the effect of Comprehensive Everglades Restoration Plan (CERP) implementation on the Florida Bay ecosystem.

Conceptual model of DOM processing (N steps in red):



Study Area

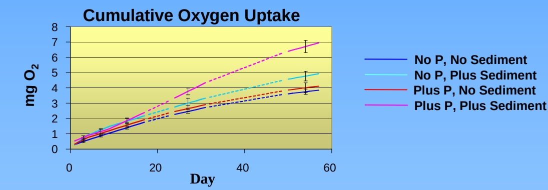


Methods

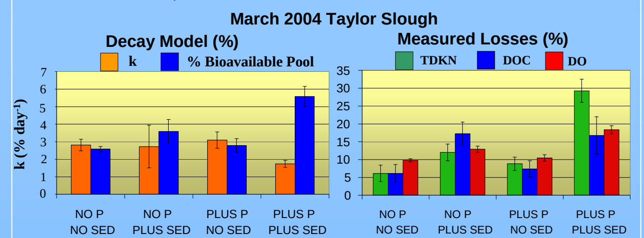
Dissolved oxygen (DO) uptake rates were measured to estimate Everglades DOC and DON decomposition during two month experiments. Taylor Slough (TS) or Shark River Slough (SRS) water (from mangrove zone ponds) was filtered (0.2 um) to exclude ambient microbes. TS was sampled in March 2004 and July 2005; SRS was sampled in August 2005. Salinity was increased using NaCl to match that of Florida Bay (34 psu). Water was distributed into quadruplicate (per treatment) 2.5 liter polycarbonate bottles. An innoculum of bacterioplankton (5 ml l^{-1} of GF/F filtrate, collected at Duck Key) was added to each bottle. Factorial experiments were run with two factors: 1) amendment of phosphate (yielding 5 µM P) to test P limitation effects; and 2) amendment of sediment slurry (1 g l^{-1} wet weight) to test benthic microbial community and particle effects on DOM decomposition. A sediment control (slurry in artificial seawater) corrected for sedimentary DO demand and material regeneration. Bottles were incubated in the dark at 25ºC. DO uptake in subsamples was measured in triplicate 60 ml BOD bottles. Total dissolved and inorganic nutrient changes were also measured.

Results

Oxygen uptake from TS water (spring 2004 sampling) are presented as the cumulative DO uptake in mg O_2 l^{-1}. The solid lines represent the time and duration of BOD incubations. The error bars are standard deviation.

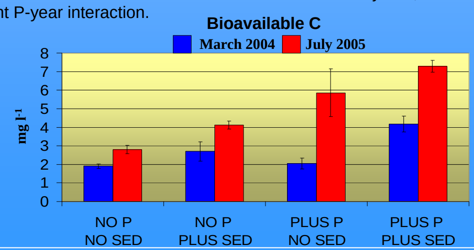


From DO uptake results, we used a first order decay model to calculate the minimum bioavailable carbon pool and decay constant for this pool (per experimental bottle, with linear regressions of LN transformed DO rates). Results from the March 2004 TS experiment (see above) show DO uptake (and therefore DOM consumption) was highest in the P plus sediment treatment. Measured DOC and TDKN losses were similar to C loss estimated from DO uptake and all metrics showed similar treatment trends. Decay rates of 2-3 % d^{-1} for a bioavailable carbon pool size of 13-28 % of the initial DOC were calculated.

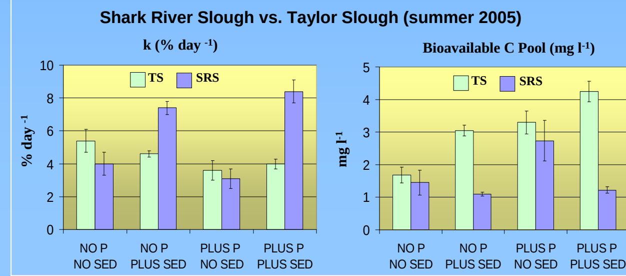


ANOVA results suggest that both P and sediment, with a significant interaction, affect the size of the bioavailable DOM pool (p<0.01). The decay rate (k) of this pool was not significantly (p>0.05) affected by any treatment.

Temporal Variability. DOM decomposition rates in samples from the TS site were compared between spring 2004 (dry season) and summer 2005 (early wet season). Initial DOC was higher in the 2005 than 2004 samples(18.5 mg l^{-1} vs 14.9 mg l^{-1}). From DO uptake rates over 60 days, we estimate the bioavailable carbon pool was also larger in 2005 than 2004 (p<0.01 for pool magnitude and bioavailable proportion of total DOM), but that the decay rates of bioavailable DOM were not significantly different between years (range 1.7-3.1% d^{-1}). The bioavailable C pool size ranged from 13-28% in 2004 and 16-39% in 2005. ANOVA results showed significant P and sediment effects on the bioavailable pool size. While the sediment effect did not differ between years, there was a significant P-year interaction.



Regional Differences in DOM Decomposition. Preliminary comparison of DO uptake rates (over the first 30 days) in summer 2005 samples from SRS and TS showed significant differences between sites for both decay rates and bioavailable pool sizes. Decay rates were higher in SRS than TS (3-8% d^{-1} versus 4-5% d^{-1}), while the bioavailable C pool was smaller in SRS than TS (8-18% versus 9-23%). Phosphate amendment had a significant effect on the bioavailable pool size (> pool size with +P) and there was a significant site interaction for this P effect. P had a small, but significant effect on decay constant values (lower k with +P). Sediment amendment appeared to strongly affect decay constant values, but not the bioavailable pool size.



Discussion and Conclusions

- DOM decay dynamics were estimated via changes in DO, DOC, and DON. Each approach yielded a similar estimate of DOM bioavailability. This result is consistent with stoichiometric assumptions required to use DO measurements to address questions about DON fate in Florida Bay.
- About 15% to 30% of the DOM in water flowing toward Florida Bay appears to be bioavailable, with decay rates of about 1% d^{-1} to 3% d^{-1} estimated over a 60 day period. Given the long residence time of water in Florida Bay (likely 3 to 12 months), these results indicate that most of the bioavailable DOM will be mineralized within the Bay. DOM decay results will be used in a water quality model to assess Everglades restoration plans.
- DOM decay varied not only as a function of DOM source, but also as a function of environmental conditions. Both P availability and the presence of sedimentary particles (with associated microbes) altered the estimated size of the bioavailable DOM pool. Decay rates, estimated by a one pool first order model, appeared less sensitive than the bioavailable pool size to these factors. Experimental results indicate that Everglades DOM will be decayed most extensively in those regions of Florida Bay that have relatively high P availability (western regions), especially in association with suspended particles and at the sediment-water interface.
- Results from these initial experiments are consistent with the expectation that wetland hydrologic conditions affect both the quantity and quality of DOM export to estuaries. The highest concentration and proportion of bioavailable DOM found to date was in the July 2005 Taylor Slough sample, which occurred in the early wet season, with the first pulse of freshwater through the saline wetland.
- Estimates of decay dynamics likely will be improved by use of a multiple pool decay model. Decay rates and pool sizes estimated from a single pool model varied as a function of the duration of the incubation, with more rapid decay (k values) early in the experiment.