The Age and Lability of Organic Carbon in Headwater Catchments With Varying Land Use

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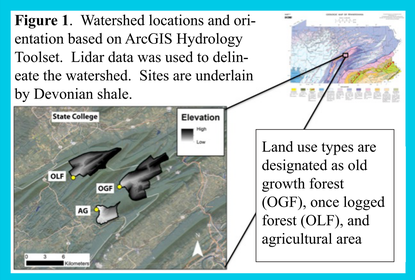
Project Goals and Outline

Recent studies have shown that the age of dissolved organic carbon (DOC) and particulate organic carbon (POC) being transported by large river systems on the east coast of the United States can be several thousand years old and recalcitrant in nature. Carbon age in large river systems may be obscured by factors such as carbon production, large-scale land use, and sewage treatment plants. We are studying three headwater catchments with varying land uses to better understand organic carbon age, lability, and the processes that control the export of this material to larger river systems. We hypothesize that land use plays a critical role in controlling the watershed hydrology and organic carbon dynamics of these catchments. For the past year, we have captured two storm events and sampled soil horizons along a catena within an old growth forest, once logged forest, and agricultural area.

The streams were sampled in late summer and spring to assess seasonal changes in DOC composition and quality. Soil horizons were restricted to the upper 30 cm and were sampled during the summer. In most locations we combined the O/A-horizons and sampled the B-horizon separately. One site contained an E-horizon. DOC and POC samples from baseflow and peak DOC concentration in both storms were radiocarbon dated. DOC and POC leached from specific soil horizons were also radiocarbon dated. We assessed DOC biolability throughout the course of the storm events and for each soil horizon. As the bulk of organic matter is exported from watersheds during storm events, we hope to clarify the age and lability of the organic matter within our study catchments, with the intent of showing how this may influence larger river systems.

Sampling Locations/ Methods

Figure 1. Watershed locations and orientation based on ArcGIS Hydrology Toolset. Lidar data was used to delineate the watershed. Sites are underlain by Devonian shale.

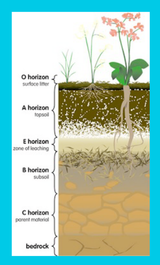


Land use types are designated as old growth forest (OGF), once logged forest (OLF), and agricultural area

Storm Sampling

The use of automated ISCO samplers allowed us to sample continuously through 24 hour storm events. We used paired level loggers, cross sectional measurements, and the Manning equation to model discharge (cms) at each of our stream locations.

Soil Sampling



Soil pits were dug along a catena within each watershed (high, middle, and low). About 10 grams of soil from specific horizons were extracted into 500 mL glass flasks. Extractable organic carbon was isolated by quartz fiber filtration after 24 hours of leaching with ultra pure DI water.

Biolability

DOC biolability was assessed over a 20 (soils) and 60 (stream) day period by measuring changes in concentration with an automated TOC Analyzer

Biolability = ((Initial - Final)/Initial) *100

C-14 Age

DOC

Stream samples were filtered within 12 hours of collection. DOC samples were purified and converted to CO2 using a photo-oxidation method at Yale University. CO2 was converted to graphite and analyzed for C-14 at the UofA AMS lab.

POC

POC was collected on replicate quartz fiber filters. Until analysis, samples were frozen. They were then thawed, dried at 60 °C for 24 hours, and combusted in quartz tubes at 800 °C with CuO. CO2 was purified and converted to graphite at the UofA AMS lab.

1. Watershed Characteristics

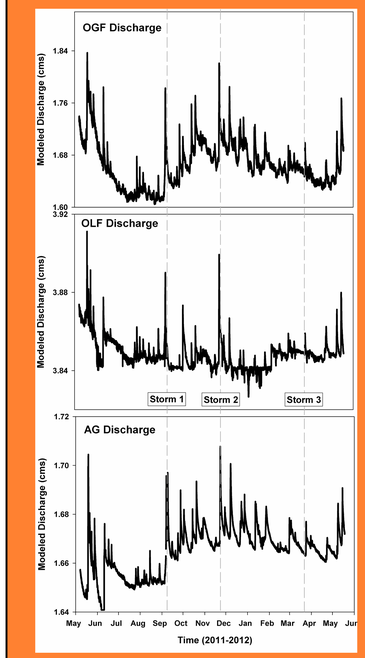


Figure 2. Modeled Discharge Hydrographs

Extractable DOC Concentrations

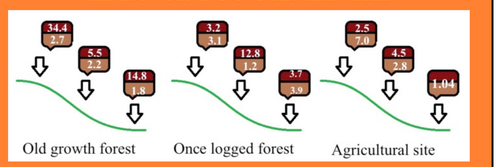


Figure 3. Extractable DOC concentrations in mg/L. Top is O/A horizon, while bottom is B horizon. In the OLF, there was an E horizon at the low elevation. We defined a mixed layer at the low AG elevation.

Streams

- Streams were sampled in September, November, and March of 2011-2012.
- Soils were sampled in June of 2012.
- The hydrograph suggests a "loading" period before storm 1.

Soils

- Soil DOC concentrations were variable.
- The OGF site contained the highest concentrations of extractable DOC. Much of this was found in the high elevation A horizon.

2. The Age of Organic Carbon

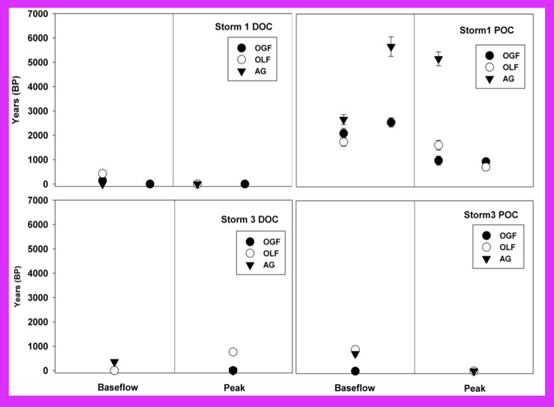


Figure 4. DOC and POC ages of stream samples for Storms 1 and 3. Samples were divided into "baseflow" and "peak" discharge. Replicate samples are shown in the second column of data for each parameter. Ages are reported in calibrated years BP with a 2 sigma error. There were clear differences in organic carbon recruitment between Storms 1 and 3.

Land Use Type	Horizon	Elevation	Analysis Type	C-14 (yrs BP)
OGF	B	Low	POC	post-bomb
OGF	B	Low	DOC	post-bomb
OGF	B	Mid	POC	post-bomb
OGF	B	Mid	DOC	post-bomb
OGF	B	High	POC	post-bomb
OGF	B	High	DOC	post-bomb
OLF	E	Low	POC	post-bomb
OLF	E	Low	DOC	post-bomb
OLF	B	Low	POC	52.5 ± 26
OLF	O	Low	POC	post-bomb
OLF	B	Low	DOC	79.5 ± 94
OLF	B	Mid	POC	post-bomb
OLF	B	Mid	DOC	post-bomb
OLF	B	High	POC	post-bomb
OLF	B	High	DOC	post-bomb
AG	Mixed	Low	POC	post-bomb
AG	Mixed	Low	DOC	post-bomb
AG	B	Mid	POC	post-bomb
AG	B	Mid	DOC	post-bomb
AG	B	High	POC	post-bomb
AG	B	High	DOC	post-bomb

Figure 5. DOC and POC C-14 ages of specific soil horizons within each watershed.

3. DOC Biolability

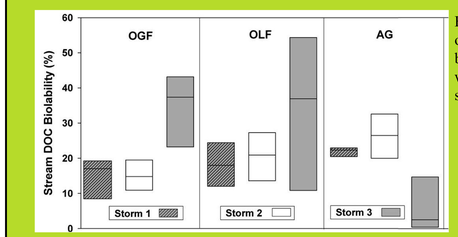


Figure 6. Range of stream DOC biolability values within each watershed.

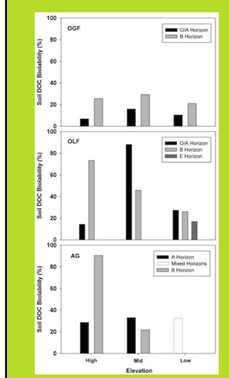


Figure 7. DOC biolability by soil horizon and elevation within each watershed.

- DOC lability ranged between 0 and 55% in our headwater streams during storm events. (Figure 6)
- Soil horizon biolability was extremely variable (0-90%). (Figure 7)
- The lack of vegetation in the AG area suggests that there was available carbon on the forest floor that allowed stream communities to increase the amount of organic carbon utilized during respiration.
- We observed lower biolability values in the soil DOC. There was no correlation between catena elevation and biolability. B horizons tended to have higher biolability values than O/A or E. (Figure 8)

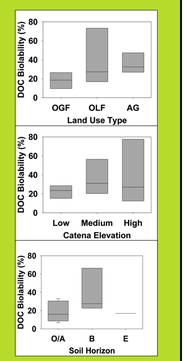


Figure 8. DOC biolability of soils by land use type, catena elevation, and soil horizon.

Conclusions

1. The data indicate that a young, rapidly recycling pool of DOC exists in all of the watersheds. Small portions of older DOC can be found in the forested catchments.

2. The recruitment of POC in the streams is likely the result of bank erosion. We observed younger POC age with increasing discharge which suggests a surface input (younger carbon).

3. Land use controls the export of POC. We observed the oldest POC export from the AG site (Storm 1). The older ages observed in this storm may be the result of hydrologic "loading."

4. Biolability in the streams and soils was variable in nature. The OGF contained recalcitrant DOC as we observed lower values in this catchment.

5. Land use plays some role in controlling the export and lability of organic carbon. More sampling is needed to confirm spatial and temporal patterns observed in the data.

Acknowledgements

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