Dissolved Organic Carbon within Stream Waters of the Great Smoky Mountains

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Abstract

Despite recent decreases in atmospheric acid deposition, many watersheds of Great Smoky Mountains National Park (GRSM) have lacked expected corresponding increases in stream water pH. Dissolved organic carbon (DOC) concentrations in stream waters have drawn attention as the possible cause. DOC contributions to stream waters are a major portion of watershed carbon cycling with known influences on broad water quality parameters, such as acidity, nutrients, and dissolved metals (Evans, 2005; Lawrence, 2013). Lawrence & Roy (2020) noted that increased ionic strength within the soil matrix during acidification compressed the diffuse layer which reduced organic carbon solubility and enhanced aggregation of organic matter which has been reversed by the recent reductions in acid deposition. However, whether this biogeochemical process dominates stream acidity is dependent on many potential watershed factors, such as vegetative cover conditions, elevation, slope and soil type, depth and chemistry.

Because of the substantial reduction in acid deposition in GRSM, there is a need to investigate this potential concept and better understand the current streamwater quality conditions. Water sampling and data collection are being conducted in a similar manner of past research by focusing on large-scale influencers including topography, geology, pedology and climate (Neff, 2013). Additionally, comparisons of DOC with other chemical constituents, namely inorganic acids and base cations, will provide a better understanding of the biogeochemical relationships. Ultimately, development of predictive models generated from this research would provide a useful tool for the comprehensive approach to natural resource maintenance being undertaken by GRSM management departments.

REFERENCES

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Research Questions

1. Following reductions in atmospheric deposition of inorganic acids, what are the current dissolved organic carbon (DOC) concentrations in stream waters of Great Smoky Mountains National Park (GRSM)?

2. What influences DOC concentrations in GRSM watershed?

3. What is the contribution of DOC to delayed recovery of streams from acidification in GRSM?

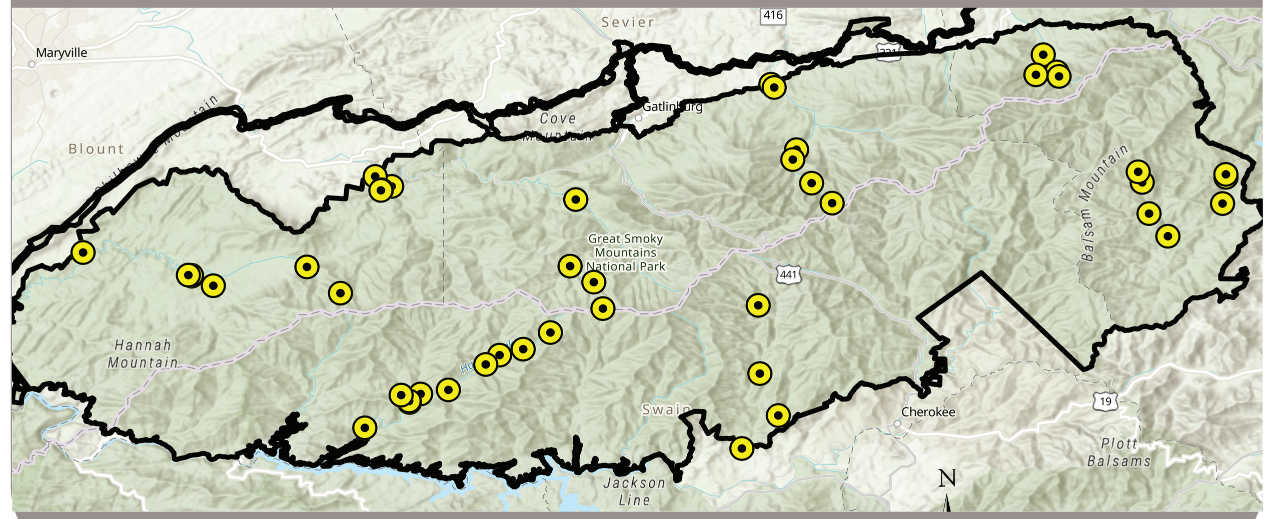
4. Can DOC be modeled to forecast concentrations within GRSM and its watersheds?

Field Methods

- Each site visited on a bimonthly basis beginning in January 2020 and ending in November 2020
  - *Exceptions:*
  - March 2020 due to travel concerns related to the covid-19 pandemic
  - HAZ limited to November 2020 only due to logistical difficulties
- Sampling accomplished through grab sampling with assistance of GRSM and Trout Unlimited (TU) volunteers
- DOC measured in accordance with the United States Geological Survey (USGS) non-purgeable organic carbon analysis method
- Comparison parameters acquired through the National Park Service (NPS) "Vital Signs" monitoring program (pH, ANC, & ion concentrations) and USGS Streamstats application (drainage area & site elevation)

Study Sites

- Seven watersheds of interest selected by GRSM staff as representative of parkwide conditions
  - Abrams Creek (ABC), Cataloochee Creek (CAT), Cosby Creek (COS), Deep Creek (DPC), Hazel Creek (HAZ), Little Pigeon River (MPLP) & Little River (EPLR)
- Watershed sample site density range: 4 sites (COS) – 10 sites (HAZ)
- Sample site elevations range: 335 m - 1667 m
- Watershed drainage area range: < 1 km2 - 275 km2

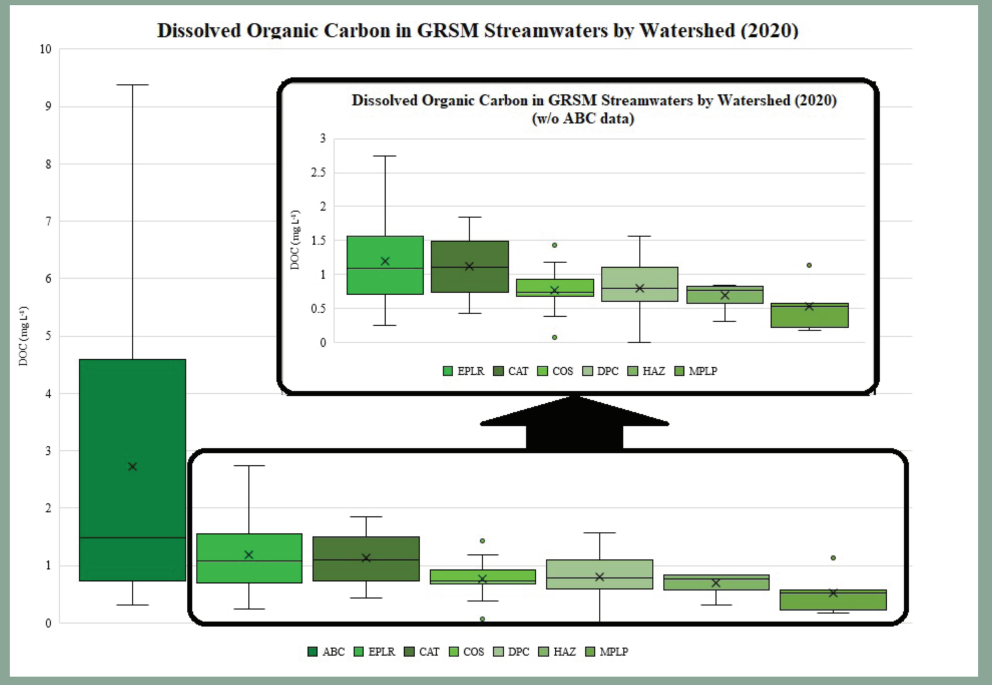


Statistics Applied

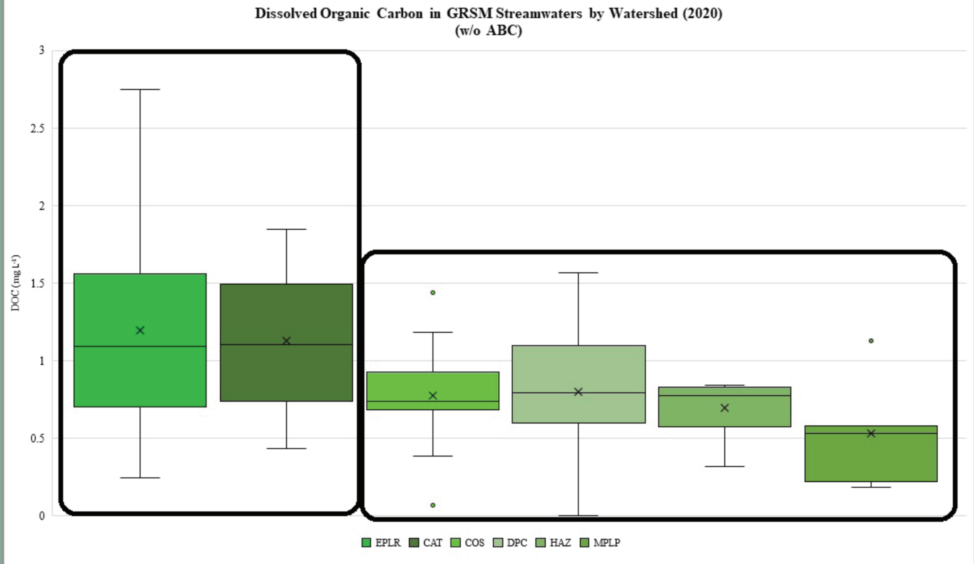
ANOVA & Tukey HSD test (SPSS), Linear Regression (Excel), PCA & CCA (PC-ORD)

Key Findings

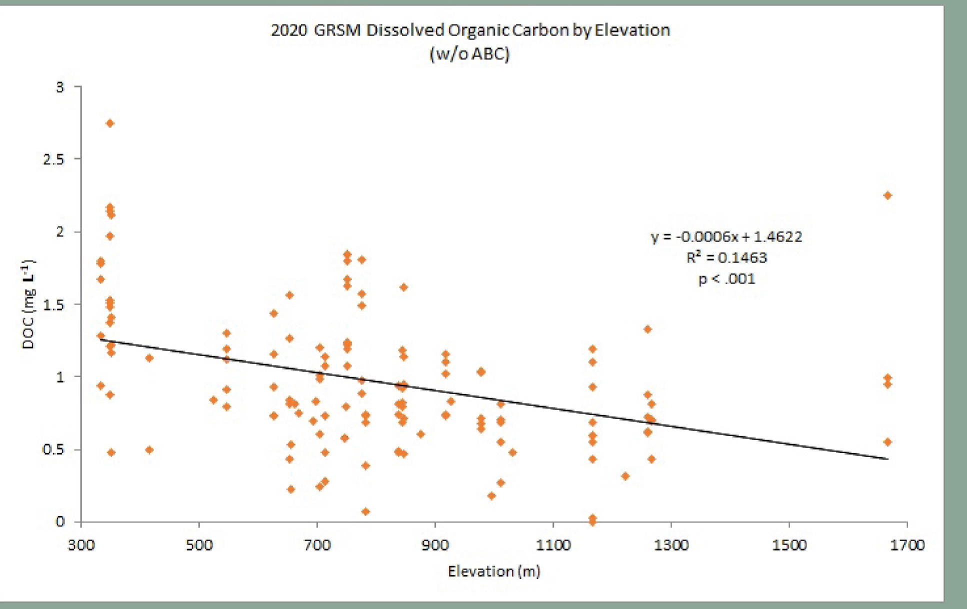
Watershed	# Samples	Min (mg L^{-1})	Max (mg L^{-1})	Mean (mg L^{-1})	Std Dev (mg L^{-1})
Abrams Creek	35	0.311	9.378	2.718	2.467
Cataloochee Creek	35	0.433	1.845	1.127	0.412
Cosby Creek	20	0.069	1.437	0.772	0.296
Deep Creek	25	0.000	1.565	0.798	0.384
Hazel Creek	10	0.316	0.838	0.696	0.178
Little River	38	0.245	2.745	1.192	0.610
Little Pigeon River	7	0.181	1.129	0.531	0.312
Total	170	0.000	9.378	1.329	1.385
Total (excl. Abrams)	135	0.000	2.745	0.969	0.489



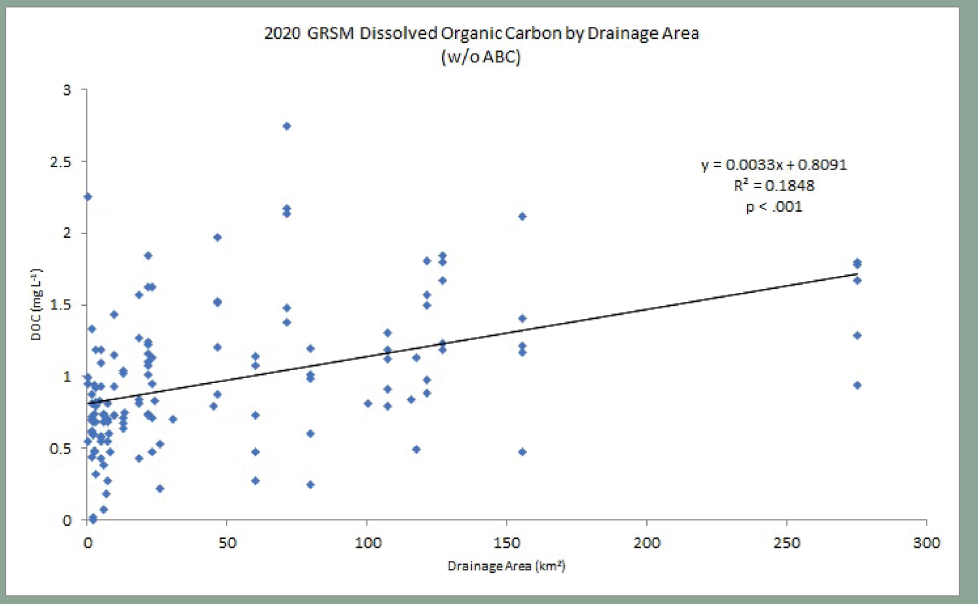
- ABC heavily skews data when considered with all other target watersheds
  - ABC isolated from further DOC comparisons
- EPLR and CAT DOC concentrations differ significantly from all other target watersheds ($p < .001$) but not from each other ($p = .599$)



- DOC has significant ($p < .001$) but weak ($r2 = .146$) negative relationship with elevation



- DOC has a significant ($p < .001$) but weak ($r2 = .185$) positive relationship with drainage area



- Stepwise regression analysis (SPSS) with additional chemical conditions (pH, ANC & ionic concentrations) in progress