Assessment of Drivers in Virginia Reservoir Water Clarity

Jackson Barnett, Paul Bukaveckas
Virginia Commonwealth Unviersity
Center for Environmental Studies
barnettj8@vcu.edu

INTRODUCTION

The clarity of water in lakes/reservoirs is dictated by two main processes: light **scattering** and light **absorption**. Scattering is caused by suspended particulates in the water column deflecting light particles as they enter water. Alternatively, when organic material is dissolved in waterbodies, it adds coloration to the water, this dissolved color then absorbs light particles as they pass through (See Figure 1).

Water clarity can become impaired due to:
- **Excess sediment** presence that causes greater light scattering
- Increased **algal presence** which scatters and uses light for photosynthesis

Water clarity is measured by determining the **light intensity** at various **depths** using an underwater probe. Clarity is important because decreased light availability is associated with increased **algal blooms**, sediment **resuspension**, and decreased **submerged aquatic vegetation**.

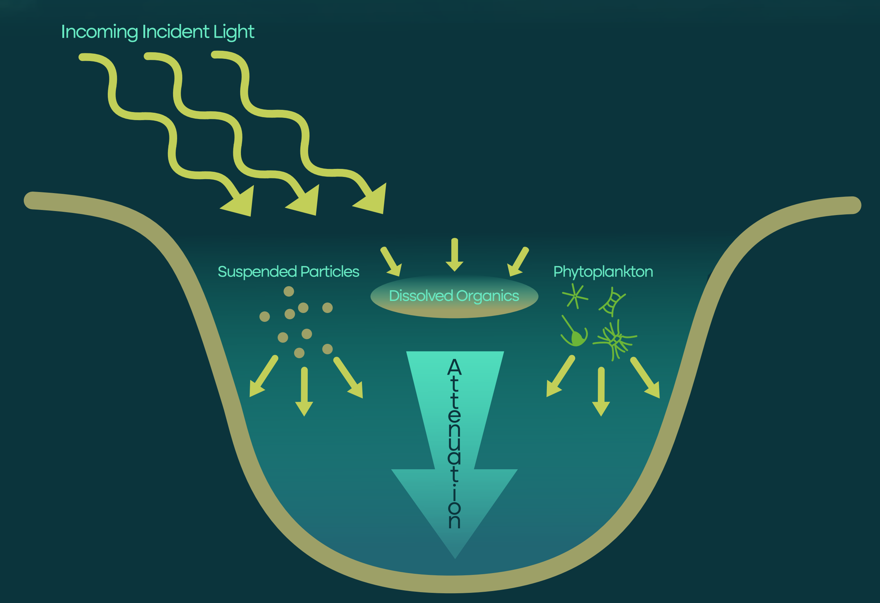

Figure 1: Diagram of Light Interactions in Reservoirs

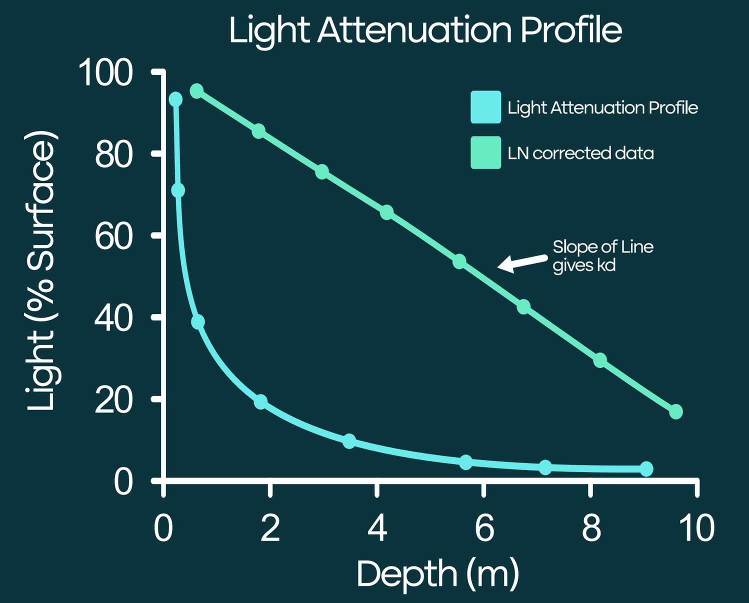

Figure 2: Light Attenuation Curve and kd Slope Graph

Objective

To evaluate the role of abiogenic sediments, algae, and colored (chromophoric) dissolved organic matter in the water clarity of Virginia reservoirs.

METHODS

Study sites are being monitored in conjunction with the Virginia Department of Environmental Quality to allow for joint data/sample collection. Primary data collection is being conducted this **May-October** with the exception of Lake Anna which receives year-round monitoring. **Thirteen stations** are being monitored across **seven reservoirs** spanning **two ecoregions**. The reservoirs in this study are shown in Figure 3:

1. Lake Anna	Piedmont	One Site
2. Harrison Lake	Southeastern Plains	One Site
3. Chickahominy Lake	Southeastern Plains	One Site
4. Fort Barfoot Reservoir	Piedmont	Two Sites
5. Briery Creek Lake	Piedmont	Two Sites
6. Sandy River Reservoir	Piedmont	Three Sites
7. Swift Creek Reservoir	Piedmont	Four Sites

Light attenuation is analyzed by converting underwater light profiles into a **light attenuation coefficient (kd)** (see Figure 2). Total Suspended Solids (TSS), Chlorophyll-a (CHLa), and Chromophoric Dissolved Organic Matter (CDOM) are being analyzed as the primary predictors of kd.

- Light attenuation coefficient (**kd**) represents overall clarity of water
- **TSS** (mg/L) represents concentration of abiogenic sediment in water
- **CHLa** (ug/L) is the concentration of aquatic photosynthetic cells (algae)
- **CDOM** represents the coloration of water from dissolved organic matter

Supplimental Materials: Read the Original Full Project Proposal, View More Details on Project Design, Methods, and Future Plans for this Study, & Add Me on LinkedIn

HYPOTHESES

H1 Abiogenic **sediments** will influence light attenuation in **Piedmont** region reservoirs more, as greater topographic variation results in higher sediment yields.

H2 **Algae** will have a strong influence on water clarity in lowland areas (**Piedmont** and **Southeastern Plain**) where high agricultural activity results in excess nutrient loads.

H3 **Dissolved color** influences will increase in importance in the **Southeastern Plain** where predominantly sandy soils allow leaching of CDOM from vegetation.

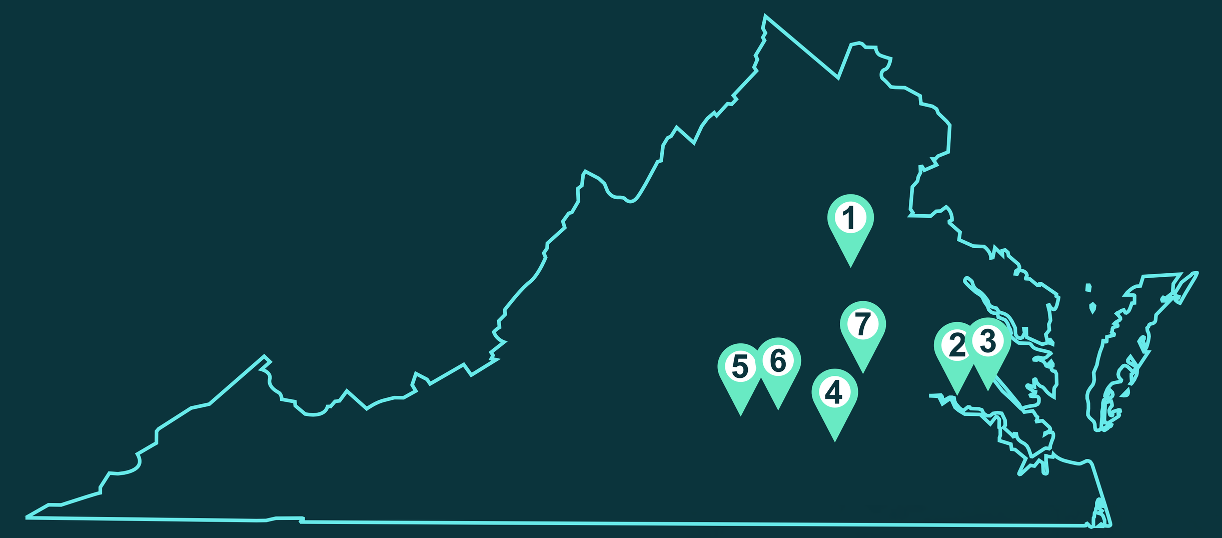

Figure 3: Map of Seven Study Reservoirs in Virginia

RESULTS

Univariate, linear regressions were used to model relationships between light attenuation with CDOM, TSS, and CHLa (Figures 4, 5, and 6). **CDOM** was identified as the **strongest initial predictor** with an R^2 of 0.6622 and $P < 001$. Figure 4 model was used to determine the proportion of kd attributed to CDOM effects.

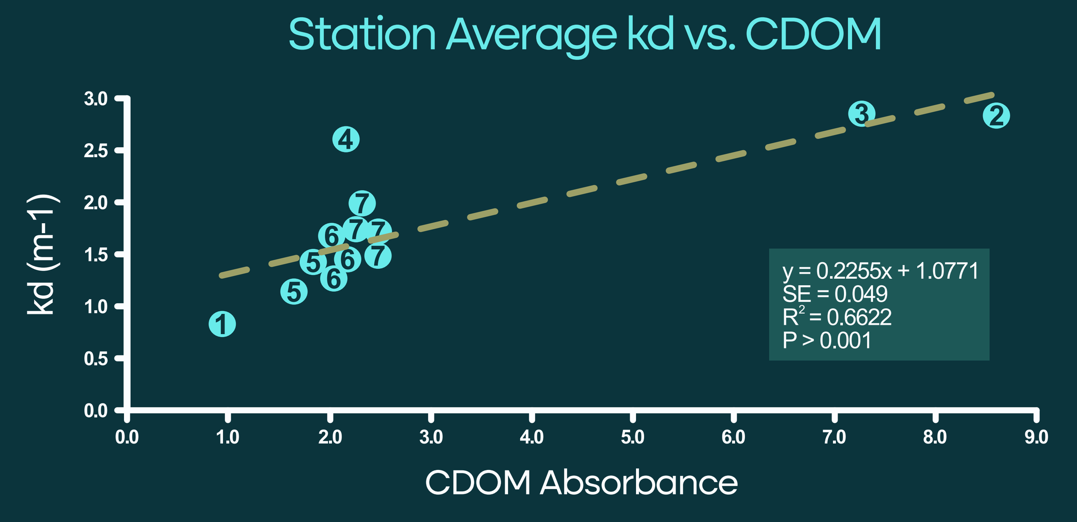

Figure 4: Linear Regression Model Output of Station Average kd vs. CDOM

- Remaining kd minus CDOM effects were used for TSS and CHLa analysis
- Average **TSS** was **correlated** significantly with **kd** at all stations (R^2 of 0.9659 and $P < 0.0001$)
- **CHLa** accounted for little variation and was **insignficant** due to a high standard error and a P-value of 0.54.

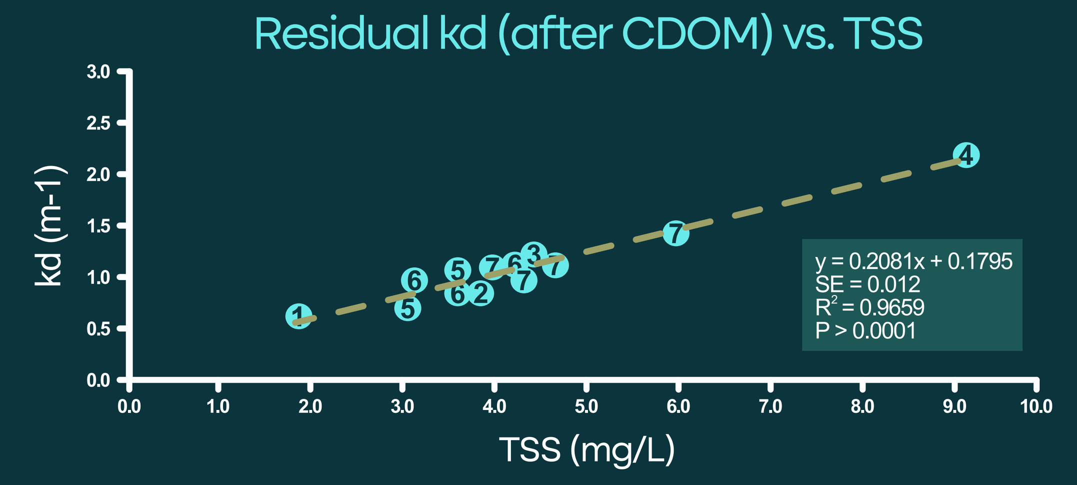

Figure 5: Linear Regression Model Output of Residual kd After CDOM vs. TSS

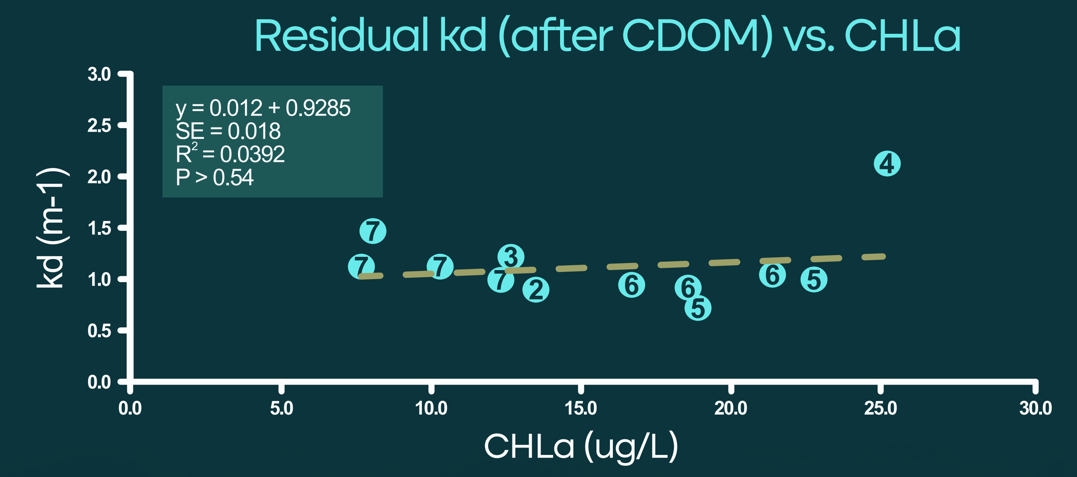

Figure 6: Linear Regression Model Output of Residual kd After CDOM vs. TSS

Regression slopes for both significant predictors (CDOM and TSS) were used to find the **percent contribution** each variable made towards **kd** at each station. Figure 7 visualizes the effects that CDOM and TSS each had on light attenuation across sites.

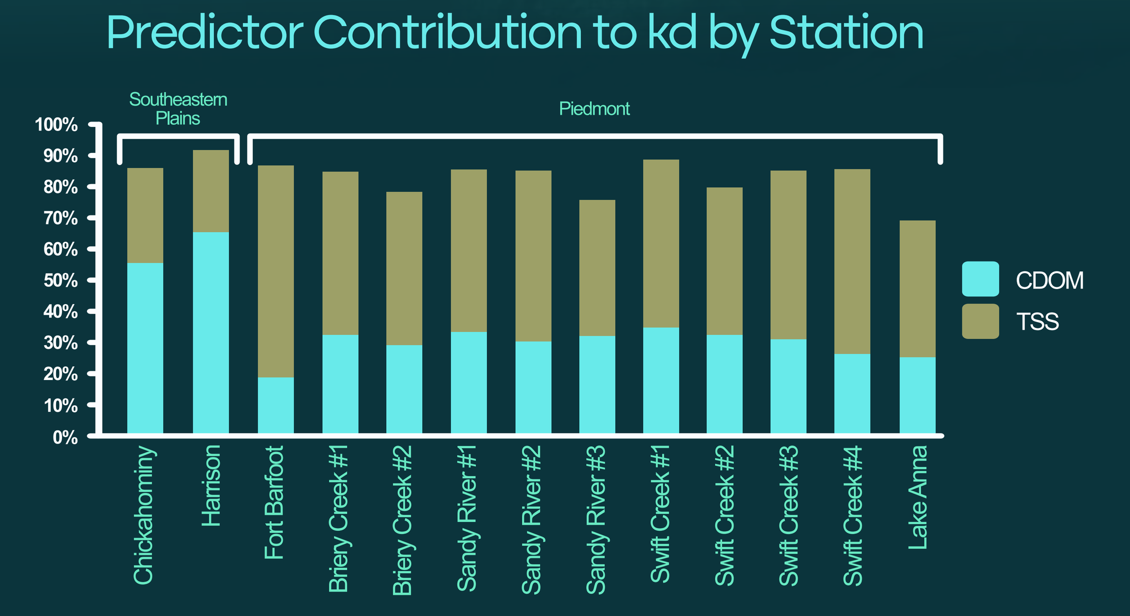

Figure 7: Comparison of TSS and CDOM Effects on kd at Each Station

CDOM exhibited the highest influence on kd in the two **Southeastern Plain** sites, Harrison Lake and Chickahominy Lake. There, the effects of CDOM account for 69% and 58.1% of the kd variations at each site respectively. At other sites, CDOM influence accounted for 30.3% of fluctuations on average. **TSS** affected the kd at Fort Barfoot most heavily (73.2%), but also had a **significantly strong** influence across all **Peidmont** sites (average of 56.9%).

- Average of 88.3% of kd fluctuations across sites is explained by CDOM + TSS
- Approximately 8.5% of kd is typically attributed to normal water absorption

CONCLUSIONS

H1 Abiogenic **sediments** had stronger influences in the **Piedmont** region, potentially from topographic variation and subsequent sediment yields.

H2 **Algae** showed little influence on water clarity across **Piedmont** and **Southeastern Plain** regions.

H3 **Dissolved color** influences were greatest in the **Southeastern Plains** regions where predominantly sandy soils likely cause greater leaching of CDOM from vegetation.

Findings indicate that water clarity in Virginia reservoirs is largely determined by **natural processes** (the leaching of dissolved organic matter from terrestrial vegetation, i.e., CDOM). Among factors contributing to light attenuation, **suspended particulate matter** (TSS) was found to be **important**, while **algae was not**. This suggests that measures to **reduce soil erosion** and sediment transport throughout watersheds would improve water clarity of Virginia's reservoirs.

This project is ongoing and we will continue collecting data through October. The second chapter of this project will append long term historical data to our analysis (see QR code for more info) .

Acknowledgements
Mike Shaver and Warren Smigo (DEQ)
William 'Mac' Lee (VCU Analysis Lab)
Harry Looney and Peter Kendrick (LACA)
Drs McGarvey, McCallister, and Vonesh (Research Committee)