

Chapter 71

Water Quality Estimation Using Combined Water Chemistry and Field Spectroscopy in the Shenandoah River, Virginia

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ABSTRACT

This study investigated the spatial dynamics of water quality across the Shenandoah River basin using spectroscopy and chemometrics to estimate chlorophyll (Chl), colored dissolved organic matter (CDOM) and turbidity using three band combinations and nutrients (total nitrogen and total phosphorous) in the Shenandoah River. The mean Chl a concentration for 555 nm, 560 nm and 640 nm were; 0.31 µg/l, 0.33 µg/l, and 0.51 µg/l respectively. Chlorophyll a showed strong correlations at band 640 ($r = 0.92$). The bands centered at 670/490 were the best in predicting CDOM and turbidity in the Shenandoah River Basin with an $r^2 = 0.56$. Chemometrics analysis show that total phosphorous, nitrogen and turbidity can be predicted between 450 to 555nm and 670 to 710 nm, the range of wavelengths which indicated better predictability for spectroscopic analysis. The resultant concentration is used to develop predictive models to determine sensitive spectral variables for nitrogen, phosphorous, Chl-a, and CDOM.

1. INTRODUCTION

Water is one of the most essential and valuable and essential resources for life on earth and there is an ever-increasing stress on water resources as population increases, there is an ever-increasing stress exerted on water resources (McGwire et al., 2000). Sustainable water resources management requires continuous and accurate monitoring. Satellite observations has provided data for such monitoring for several

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years (Landgrebe, 1999) and has served as a time and the cost-effective way to carry out large-scale monitoring (Okin et al., 2001), “which can be used to determine the quality, quantity, and geographic distribution of this resource” (Govender et al., 2006). Water pollution is a significant environmental issue, further limiting the availability of water for human and environmental use. In the Shenandoah River, several natural and anthropogenic processes affect the quality of streams and ground water. According to the Virginia Department of Environmental Quality the Shenandoah River is also “under the under stress from a variety of human uses and influences, from water supply demands, waste disposal and irrigation, to hydropower, transportation and recreation”. Common major chemicals found in the Shenandoah Basin include nutrients (nitrogen and phosphorous), “pesticides, trace elements, volatile organic compounds and chlorinated industrial compounds” (USGS, 1998). Although nutrients are essential for plant and animal growth and nourishment, an overabundance of some nutrients in water can disturb the river (Mueller & Helsel, 1996). Pollution incidents in the Shenandoah have been reported by the Environmental Quality Department, between 1929 and 1950, where mercury waste from a now-defunct DuPont Co. facility contaminated the South Fork from Waynesboro to Front Royal. McGovern (2014), in a recent article on the Rockbridge report, stated that mercury levels have mostly settled and do not appear to pose a significant health threat, although its concentrations have not declined. The report also indicates that the river continues to maintain mercury advisory, the sponsorship of scientists by DuPont to monitor fish health and water quality has remained in place (McGovern S., <http://rockbridgereport.washingtonandlee.net/?p=7053>).

The Shenandoah serves as a popular fishing destination in Virginia (Virginia Association of Soil and Water Conservation Districts). However, fish deaths were observed for almost two months in 2003, from April to the end of May, when the bacteria causing fish death subside as result of warm waters. The Shenandoah River was affected by massive fish kill between 2003 and 2006, as reported by the Virginia Department of Environmental Quality. The Fish kill in 2003 was observed at the North Fork, and in 2004, it occurred along 100 miles of the South Fork Shenandoah. Virginia Department of Environmental Quality also reports that; about 65 percent of the fish population had died by 2005, which is 13 times the number of fish death that observed in the river for a normal year (McGovern S., 2014; <http://rockbridgereport.washingtonandlee.net/?p=7053>). Almost a decade after this fish kill incident, its cause has yet to be identified, although a bacteria known as *Aeromonas salmonicida* which is known for causing afflictions on fish has been identified. This bacteria cause minor to fatal tissue damage that can cut as deep as a fish’s backbone to the affected rivers, and this fish kill has impaired the river (Ripley et al., 2008). Although the fish kill rate has reduced since 2005, *Aeromonas salmonicida*, which does very well under cold water conditions, and thrives with temperatures below 65 degrees year-round.is still present in the Shenandoah and nearby waters. The Shenandoah river also has an estrogenic compounds that can induce intersex (Lange et al., 2009 & Hahlbeck et al., 2004) and this has a negative effect on the o the fish immune function (Iwanowicz and Ottinger, 2009 & Robertson et al., 2009). The Virginia Game and Inland Fisheries Department is still to discover what is causing the presence on this bacterium in the Shenandoah River which is a warm water body. Also, pharmaceuticals and hormones from sewage treatment facilities contribute to the fish deaths. Virginia Department of Environmental Quality, also reports that, many endocrine disruptors, such as certain soaps, found in household products have an effect on fish immune systems. Although a direct correlation between endocrine disruptors and the fish kills, have not been identified, it is believe that pharmaceuticals, pesticides and parasites have brought added stress to fish immune systems, affecting their ability to fight (Virginia Department of Environmental Quality).

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