South Carolina stormwater detention ponds: Sediment accumulation and nutrient sequestration

William Schroe***1, Claudia Benitez-Nelson**1, Erik Smith**1,2, Lori Ziolkowski**1

1School of the Earth, Ocean, & Environment 2Baruch Institute of Marine and Coastal Sciences

*wschroer@geol.sc.edu University of South Carolina

Introduction

Stormwater detention ponds are prevalent across South Carolina and receive runoff waters carrying both nutrients and sediments. As sediments accumulate in these ponds, water volume is reduced leading to a decrease in runoff retention. Periodic dredging is required to maintain pond function, but dredging is costly and there is little data available to support how often pond dredging is required. It is further unknown how high nutrient loading effects sediment nutrient sequestration and autochthonous production of organic sediment components. The objectives of this study are to:

- Find the rate of sediment accumulation in these ponds.
- Determine the role coastal stormwater ponds play in the regional cycling of carbon and nutrients.
- Identify the sources of organic matter (external vs. internal) to pond sediments.

It is hypothesized that the answers to these questions will be dependent on a host of characteristics including, watershed development density, trophic status, and treatment regime.

Study Area

Samples were collected from 14 residential stormwater detention ponds located in the coastal regions Georgetown and Horry counties (Figure 1). To the best of our knowledge sample ponds have not been dredged since construction. Ponds were selected to represent a range of watershed development levels, from low density forested to high density urban. Percent impervious surface of pond watershed was used as a proxy for development density and was calculated using satellite imagery.

Methods

From each pond 5–8 cores were collected using a push corer (Figure 2), sectioned at 1 cm intervals, and freeze dried. Total particulate, inorganic, and organic phosphorus (TPP, PIP, POP, respectively) concentrations were measured colorimetrically after acid hydrolysis (modified from Aspila, et al., 1976). Loss on ignition derived organic carbon was calculated by multiplying the total grams lost after combustion at 500°C by the constant 0.58 g OC/g LOI (Waksman, 1943). Future carbon and Nitrogen (data not shown) were determined using a Carlo Erba Elemental Analyzer. Biomarker analysis of nalkanes in core samples provide insight into the origins of organic matter, e.g., terrestrial or aquatic, within pond sediments. Alkanes are solvent extraction, isolated using silica gel chromatography and quantified using GCMS (modified from Santos, et al., 2010). Lead-210 (half life 22.3 years) activity, for radiometric dating, was determined using a germanium well detector and the age calculated using the Constant Initial Concentration model (Appleye & Oldfield, 1978) (Krishnaswami, et al., 1971). Additional constraints on age were determined using google earth imagery in combination with real estate records.

Results, Discussion, and Future Work

Accumulated sediments were clearly distinguishable from historic sediments by the obvious differences in grain size, sediment color (Figure 2), and chemical composition. Sediment accumulation is highly variable within ponds but median accumulation rate correlates directly with percent impervious surface of watershed (Pearson’s r = 0.846, df = 13, p < 0.001) (Figure 3). Percent impervious surface may thus be used as a possible predictor of bulk sediment accumulation rate. Median accumulation rates ranged from 0.05 to 0.57 cm/yr suggesting that the time required for a 25% loss in pond volume is significantly longer than previously thought (Fig. 3).

The concentration of nutrients that are buried within sediments, per cm², is remarkably similar between all ponds considering the vast differences in watershed development and land use (Figures 4 & 5). This suggests that sediment composition is regionally uniform and therefore bulk sediment accumulation rates drive the total pond nutrient burial.

Green Bay is know to have large seasonal algal blooms. However, preliminary alkane biomarker analysis suggests that sediment POP is predominantly derived from terrestrial sources (Figure 6). Algal biomasses is likely being remineralized prior to sediment burial. As such, the nutrients fixed by algal biomass are not being sequestered, resulting in greater nutrient export to coastal waters.

Moving forward more cores from each pond will be processed in order to fill in gaps in data and better quantify within pond variability.

Acknowledgements

I would like to thank Meryssa Piper, Katie Frame, Lucas Tappa, and Blaire Umdhay for their enthusiastic help in the field collecting samples. Thank you to the Baruch Marine Field Lab for the use of their facilities and lab space. I would also acknowledge the support provided by the School of the Earth Ocean and the Environment at the University of South Carolina. Finally a warm thank you to the SC SeaGrant Consortium for funding this research and the home owners who have graciously allowed us access to their property.

References