WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: NC1461

Title: Role of Sediment Processes in Regulating Water Quality in the Cape Fear River

Focus Categories: Sediments, Water Quality

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Abstract

We selected the Cape Fear River system, the largest river system in North Carolina, since during the recent decades it has experienced a proliferation of agriculturally related industries including large-scale agricultural operations, agrochemical manufacturing, and intensive livestock operations. This has resulted in dramatic increases in anthropogenic imports of nitrogen and phosphorus into the river basin. Between 1985 and 1995 hog production in North Carolina increased by 248% and turkey production increased by 92%. North Carolina is now the second largest producer of hogs in the nation. The majority of these intensive livestock operations are located within the Cape Fear and Neuse River watersheds (Cahoon et al., 1999). Given the magnitude of increased phosphorus and nitrogen import into the watershed, even relatively effective water quality management practices will still allow considerable nitrogen and phosphorus loading to the river, thus increasing the potential for eutrophication. While the Neuse River basin has been the focus of numerous water quality related investigations (e.g. Paerl et al. 1998; Pickney et al. 1997; Paerl et al. 1995), the Cape Fear River basin has been accorded relatively little attention. However, there is a clear trend in water quality degradation on the Cape Fear River (Cahoon et al. 1999, Mallin 2000).

Although, surface waters in North Carolina rivers have been the focus of intense monitoring and research, the role of the sediment chemical environment (SCE) in regulating surface water quality has been essentially ignored. The reciprocal interaction between surface water quality and the processes occurring within the SCE underscores the need to better understand this (SCE) important but least understood class of conditions that dictate the nutrient status and quality of adjoining water bodies. We propose to use the sub-watersheds of the three Lock and Dam structures in Cape Fear river to estimate the nutrient (Phosphorus and nitrogen) retention capacity of river bank and adjoining wetland sediments. We will also explore the diversity in the forms of nutrient (phosphorus) compounds that are loaded in the Cape Fear River, due to the diversity in the land use within these sub-watersheds. With regards to our study sites in the Cape Fear

river basin (see section 13 for details), background data indicate that sediment processes play an important role. For instance, results from a USDA funded study at the Barra Farms Cape Fear Regional Mitigation Bank, reveal particulate bound phosphorus from agricultural land may be an important form of input to the Cape Fear River (Neal Flanagan, personal communication). Results from another pilot study (jointly funded by the Water Resources Research Institute and the Cape Fear River Association) show that among the three Lock-and-Dam sites, the highest concentrations of bioavailable ammonium occur in the sediments from the Lock-and-Dam # 2. The sub-watershed of this Lock and Dam has the highest density of intensive livestock operations within the Cape Fear River basin. These and other (see section 12) preliminary data suggest that SCE plays an important role in regulating water quality in rivers. The trend of water quality degradation and the emphasis on developing a long-term feasible water quality management practice in the Cape Fear River basin underscores the need for such sediment oriented study, that addresses the role of sediments as nutrient sinks while visualizing the various forms in which nutrients are loaded in the system.

Using the approach outlined in this proposed study, it is expected that we will be able to estimate the buffering capacity of wetland sediments which will not only dictate the magnitude of nutrient loading to surface waters, but will also place a time-line on the control of surface water quality. It is conceivable that, after few years of sustained nutrient loading (e.g. nitrogen and phosphorus), wetland and floodplain sediments of the Cape Fear River system will eventually become saturated with nutrients and thus will be unable to ameliorate nutrient driven surface water quality degradation. Further, the diversity of land-use within the watershed of this river system implies that the drivers of water quality degradation may also be diverse. Recognizing the diversity in the chemical forms of nitrogen and phosphorus inputs into the system is critical to developing successful water quality improvement schemes, as is understanding their fate in the environment. For example, phosphorus inputs into a system can occur in many chemical forms (e.g. orthophosphate, pyrophosphate and other polyphosphates). Some of these chemical forms (e.g. pyrophosphate (Ppi)) are more prevalent in run-off from urbanized watersheds than from minimally impacted regions (Sundareshwar et al. Limnology and Oceanography submitted). Further, these chemical forms can escape detection by the standard analysis techniques and require more sophisticated means of quantification such as 31P Nuclear Magnetic Resonance (NMR) spectrometry. Thus, understanding the relationship between land-use patterns and nutrient chemical speciation is necessary to successfully manage water quality. These new methods will allow us to determine the sources of phosphorus additions. Importantly, this study will generate information that will fill in gaps in existing data, which is the principal obstacle in developing effective long-term water quality management programs. If funded, results from this study will provide preliminary data to help develop a larger scale study for the Cape Fear River watershed.