Chapter 66
Nitrate, Total Ammonia, and Total Suspended Sediments Modeling for the Mobile River Watershed

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ABSTRACT

This paper presents details of a water quality model of the Mobile River watershed that estimates total suspended sediments at the outlet of the watershed. The model is capable of simulating Nitrate (NO_3), Total Ammonia (TAM), and Total Suspended Sediments (TSS) for extended periods of time at a daily temporal resolution (1970-1995). The Hydrological Simulation Program Fortran is used for modeling the hydrological, nitrogenous constituents, and sediment processes. Based on the nutrient simulation and exploration of the effects of two management practices (filter strips and stream bank stabilization and fencing) on nutrient removal, the resulting sediment model is used to implement the most efficient nutrient management practice and explore its effects on TSS concentrations in the Mobile River. Results show that the implementation of the management practice "stream bank stabilization and fencing" to agricultural lands in sub-watersheds that had intense agricultural activities produced the highest reductions of NO_3 concentration (up to 14.06%) and TAM concentrations (8.01%). Based on the nutrient simulation and identification of "stream bank stabilization and fencing" as the most efficient BMP for nutrient concentration reduction, the sediment model was used to explore its effects on TSS concentrations in the Mobile River. Implementing "stream bank stabilization and fencing" produced monthly median TSS concentration reductions ranging from 3.6% to 10.6% in the Mobile River.

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INTRODUCTION

The US Gulf Coast receives inputs of nutrients and sediments from intensive agricultural activities in upland watersheds (McPherson, et al., 2003). Seasonal hypoxia and high sediment load events have occurred in recent years. Continued land development and conversion of natural landscapes to urban development will exacerbate pollution (Vitousek et al., 1997; Wiener & Sassenrath, 2012). Moreover, nutrient and sediment contributions from upland watersheds where the main economic activity is agriculture play an important role (Harmel et al., 2007).

Nitrogenous constituents and sediments washed off by precipitation events from the croplands are loaded into streams (creeks, rivers) which take sediments and nutrients to coastal water bodies. Mobile Bay, an estuary located in the Alabama Gulf Coast, receives waters from one of the largest watershed in North America (Park et al., 2007): Mobile River Watershed. The estuary experiences regular hypoxic events during the summer (EPA, 2012). The Tombigbee watershed, one of the upland watersheds that drains into Mobile Bay via the Mobile River, has been identified as one of the sources of nutrient input due to its intensive agricultural activity (EPA, 2014). Increases in agricultural activities could potentially worsen the current situation. Alarcon & McAnally (2012) estimated that in a span of seventeen years some portions of the Tombigbee watershed underwent the following land-use/land-cover changes: 34% increase of agricultural lands, 263% increase of lands used for grazing or hunting animals (rangeland), and a 16% decrease of natural forest lands. With these significant changes in soil surface coverage, the transport of nutrient and sediments washed-off from this watershed to Mobile Bay and the Alabama Gulf Coast has increased proportionally. The increase of agricultural lands and agricultural intensification are anticipated to worsen the current situation (Matson et al., 1997; Harmel et al., 2006).

Conversion of forest land into crop or pasture can substantially increase the loss of sediments and nutrients from the land (Foley et al., 2005; Harmel et al., 2006). The rates of soil loss in particular will depend on management practices, especially the degree of tillage (no-tillage or conservation tillage versus conventional tillage) (Parajuli et al., 2013), and can also impact the loss of nutrients. While pastures may have reduced sediment losses, animal manures will increase the nutrient runoff from the field. A recent study at a small geographical scale (Kleinschmidt, 2005) postulated several management scenarios that may be used for reducing the effects of nutrient and sediment contamination to some of the Tombigbee streams. For cropland, filter strips, reduced tillage, stream bank stabilization and fencing, and terraces were identified as being the most useful in that order. For pasture land, stream bank stabilization and fencing, and terraces were the most useful.

The sources of nutrient and sediment loss in agricultural watersheds are mostly distributed in space (i.e., they are non-point sources). Non-point sources enhance the chances for complex physical and biochemical processes to occur during the transport of those contaminants through soil and water. Therefore, estimating the effects of nutrient and sediment wash-off from agricultural fields to streams and water bodies requires a complex quantitative approach. Watershed models are able to quantify those processes occurring either under natural conditions or due to anthropogenic activities. These models use mechanistic and empirical algorithms to calculate the hydrological processes within a watershed and also the migration of pollutants from point and non-point sources to water bodies. Previous research has shown the use of these types of models for quantification of processes in agricultural watersheds (Alarcon & Sassenrath, 2015). For the Mobile River watershed, an initial hydrological and nutrient model (Alarcon & Sassenrath, 2016) has been developed that covers all major streams in the watershed, including the