



# Research Brief #19

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## Source Identification, Transformation and Transport of Organic Pollutants in Wetlands and Upland Sediments

### Introduction

It is widely known that contamination can impair the health and functionality of wetlands. To examine basic elements of this complex problem, a multidisciplinary research team from Louisiana State University has studied how hydrological conditions affect biogeochemical processes that are major determinants of the transformation and transport of pollutants in wetlands. The biogeochemical processes investigated in this project consist mainly of sediment microbial and plant activities (growth and metabolism) as well as the physicochemical action of water, sunlight and introduction of sediments. Together, these influences are largely responsible for the productivity, habitat usage, and environmental significance of coastal wetlands. The LSU group focused on aromatic hydrocarbons (AHs) and N-, O-, and S-heterocycles (NOSHs), groups of organic pollutants found near sites of industrial activity, hazardous waste disposal sites, and major harbors. The chemical structures of AHs and NOSHs are similar but have different environmental, analytical and toxicological properties.

Scientists generally agree that the health of many ecosystems (wetlands,

river flood plains, aquaculture ponds, and rice ponds) is optimized when they experience fluctuations in physicochemical inputs (as opposed to more static conditions, in which levels of these inputs do not substantially change). One example of this concept is the effect of daily tides on coastal wetlands. It can be easily observed that the dominant salt marsh grass is much taller and more productive in sediments flushed by daily tides versus locations only a few meters away, in marsh interiors which tides do not regularly influence. It is well known that microbial processes and biogeochemical functioning are different in these locations. The biotic system appears to transform pollutants differently in areas of tidal wetlands that are hydrologically distinct—i.e., subject to pulsing of tides, continuously flooded, or continuously drained (e.g., as a result of impoundment).

Relatively limited published research has dealt specifically with the significance of different hydrological conditions regarding the processing of pollutants in coastal wetlands. Better understanding of these processes will shed light on how contaminants are affected by varied hydrological conditions produced by tides and by human changes in hydrology

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### Summary of the Problem

Coastal wetlands and estuaries account for only about 5% of the U.S. total land mass, but they serve a variety of key ecological functions—providing protected nursery and feeding grounds for fish and wildlife; catching fertile topsoil (sediments) suspended in water; purifying runoff and domestic and industrial wastewater; recharging aquifers; and transforming organic and inorganic compounds. In addition to these functions, the global wetland/estuary complex has significant economic importance—i.e., supporting the majority of the commercial coastal marine fisheries. In the past several decades, maritime fishing catches have diminished globally, while the total amount and functional quality of wetlands also have decreased dramatically.

One factor affecting the health and productivity of wetlands is pollution. Metrics (various kinds of measurements) are needed to determine if wetlands are affected by particular pollutants and to provide information on the nature and degree of changes in wetlands ecological processes. To date researchers have identified few processes than can be monitored *in situ* at the necessary resolution to provide an indication that the fundamental processes of the ecosystem are changing. Such measures need to be developed and scaled up so that they can be integrated into emerging monitoring tools such as geographic information systems (GIS). To this end, Dr. W. James Catallo and his research group at the Louisiana State University are looking for system process indicators through studies of the fate and transformation of pollutants in laboratory replicas of coastal salt marshes.

*Researchers used tide simulation mesocosms to study the impact of continuously well drained, continuously flooded, and diurnally pulsed tides on the transformation and transport of aromatic hydrocarbons and NOSH chemical pollutants often found in coastal marshes.*



(impoundments for coastal protection, waste containment, and water/sediment control). This work should provide a baseline for evaluating hydrological requirements for optimizing created and restored wetlands.

## Research Study

The most desirable way to gather data and insight on wetlands processes is extended field study. Such studies are difficult and costly because: 1) there are many variables that must be identified and monitored; 2) the logistics of site work can be prohibitive; 3) it is frequently difficult or impossible to find appropriate replicate and control sites; 4) there is extreme patchiness in these systems, and a major challenge is to find sampling sites representative of the system; and 5) it is possible that traditional linear statistical approaches and standard signal processing techniques will produce erroneous results.

The problem of field experimentation can be mitigated to some extent by the judicious use of ecological mesocosms — that is, systems of various sizes and complexity that are assembled in a controlled setting using natural and artificial constituents. The researchers designed wetlands replicas to be reliable, economical, and made of readily available parts. They started small then increased the system size. The first tidal experiments were in 20-gallon microcosms and later scaled up to 300-gallon mesocosms that more realistically represented wetlands processes. Sediments and the dominant and ecologically important marsh plant, *Spartina alterniflora* (commonly known as oyster grass or smooth cordgrass), were collected from Louisiana salt marshes, then replaced with greenhouse-grown *S. alterniflora* so that marsh integrity was not disturbed. These plants were placed in six mesocosms, with duplicates exposed to each hydrological condition: 1) *flooded-anaerobic* (oxygen-deficient microbial processes are dominant in sediments); 2) *drained-aerobic* (oxygenated microbial processes are significant); and 3) *tidal* (mildly anaerobic and aerobic microbial processes alternate with water levels).

After several months of equilibration and baseline monitoring, each mesocosm was contaminated with 100 to 350 parts

per million of AH and NOSH compounds. To determine transformation and phase partitioning of these pollutants, the researchers utilized time course sampling of slurries and water, followed by quantitative extraction and analysis using isotopic dilution. Catallo's group developed a synthetic technology (U.S. patent pending) to make the labelled standards for this approach. These analyses were conducted using gas chromatography and mass spectrometry along with capillary electro-kinetic chromatography.

## Research Results

The laboratory-scale experiments found that, in general, AH and NOSH compounds were transformed most rapidly and completely in continuously drained sediments, which were the most oxidized of all treatments. The next most potent hydrological condition for pollutant transformation occurred in wetlands subjected to tidal pulses, where sediments alternated between weakened oxidation and reduction. Transformation processes generally were slowest in continuously flooded wetlands, in which sediments were chemically reduced. Researchers found that a key step in transforming contaminants was oxidation to phenols followed by aqueous phase partitioning. This step was observed at comparable rates in drained and tidal wetlands, but less readily and in fewer compounds in flooded wetlands.

## Significance of the Research

Process metrics are needed to provide insight on how pollutants affect key ecological processes of coastal wetlands. This study supported the idea that highly resolved time-series measurements of wetlands processes (e.g., redox potential and trace gas fluxes) can serve as such indicators, complementing traditional spatial approaches. Every year, soils marginally contaminated with AHs and NOSHs are dredged from waterways and harbors and disposed in oceanic sites. If scientists improve understanding of the dynamics of ecosystem health, which include knowing how various inputs affect ecological functioning, they will be able to utilize dredged materials in wetland restoration and creation efforts.



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