Report for 2004NJ71B: Soil Moisture Regimes and Nitrate Leaching in Urban Wetlands

There are no reported publications resulting from this project.

Report Follows

Project Information

Problem and Research Objectives

Problem Nitrogen is one of the most widespread and pervasive pollutants present in surface waters throughout the United States. Excess nitrogen in surface waters can have drastic negative consequences for ecosystems. The zones of hypoxia in the Chesapeake Bay and the Gulf of Mexico are dramatic examples of the extent to which nitrogen excess can cause eutrophication in receiving water bodies. Also, because nitrate is a drinking water pollutant, elevated nitrate levels in surface waters pose a problem for human and wildlife health. These problems threaten to become more pervasive as more land is converted to urban land use.

Wetlands are increasingly being used as a management tool to combat the problem of excess nitrogen in urban watersheds. In New Jersey regional watershed management planning agencies throughout the state are emphasizing the protection and restoration of wetlands for water quality protection. This is based on the documented ability of treatment wetlands to remove nitrate in sewage effluent and of riparian buffer strips to remove nitrate from upland agricultural land use. Nitrate is removed through the process of denitrification, the microbially-mediated transformation of nitrate to nitrogen gas which is released to the atmosphere. This process requires anaerobic conditions which are found in the saturated soils of wetlands. Because of this ability to remove nitrate from upland land uses, wetlands function as nitrate sinks.

However, due to hydrological alteration resulting from urban land use, urban wetlands in northeastern New Jersey may experience lowered water tables, overall dryer conditions, and wet-dry cycles that may reduce nitrate removal capacity. In wetlands with lowered water tables, the biologically active zone of the soil where roots and microbial populations are located no longer experiences frequent saturation. As a result denitrification is inhibited. There is growing evidence that urban wetlands exposed to hydrological disturbance have a reduced ability to denitrify and thus remove nitrate before it reaches surface waters. Conversely, aerobic conditions in wetland soils, which are rich in organic matter, are well known to be conducive to high rates of nitrification. This results in the accumulation of high concentrations of nitrate and the potential for its movement through leaching to surface waters**.** This may cause New Jersey's urban wetlands to be acting as sources rather than sinks of nitrate, leading to elevated nitrate concentrations in receiving water bodies and associated impacts on the integrity of aquatic ecosystems.

Another issue which emphasizes the need to study nitrate removal in urban wetlands is the significant input of nitrogen into the system through atmospheric deposition. The density of urban development and amount of vehicular traffic in close proximity to many urban wetlands suggests that nitrogen deposition rates are significantly elevated, perhaps above regional averages, as documented along an urban-rural gradient from New York City to outlying suburbs. Several studies have explicitly linked atmospheric nitrogen deposition with eutrophication of coastal waters in the Northeast United States.

Objectives The aim of this study is to document nitrogen inputs and outputs in forested swamps along a gradient of urban to suburban conditions. This will allow me to determine whether outputs are correlated with inputs (i.e., do sites with higher nitrogen inputs have higher nitrogen outputs). This study will also demonstrate whether nitrogen inputs are higher in areas with a higher intensification of urban land use. Also, using data collected from previous work partially funded by NJWRRI, I will be able to determine whether nitrogen outputs are higher in sites with altered hydrology and in sites with higher rates of nitrogen cycling processes such as nitrogen mineralization and nitrification.

Methodology

Nitrogen inputs were measured weekly/monthly at three locations in eight sites using throughfall collectors. Sites were chosen to represent a gradient of urban-suburban conditions in forested, palustrine swamps adjacent to streams in northeastern New Jersey. The more urban end of the gradient is located in Cedar Grove and the Morristown area while the less urban end of the gradient is located in Griggstown. The throughfall collectors consist of 20 cm diameter funnels connected to four liter carboys that collect rain which has filtered through the forest canopy. Funnels are affixed one meter off the ground on PVC stakes. Glass fiber insulation filters are placed in the neck of each funnel to keep out particulate matter. Throughfall filters through the insulation and passes through tubing rinsed with deionized water into the carboys. Carboys are partially buried and exposed areas are covered with duct tape to keep out light and discourage microbial growth and activity. Acid washed funnels and carboys are placed in the field and collected one week later. No preservative or acid solution is used to prevent transformations in the carboys following standard protocols used by governmental monitoring programs like the National Atmospheric Deposition Program. Samples are transported on ice and are filtered through Whatman GF/F filters (less than 1 μm pore size -- most microbes are ~ 3 μm) immediately upon return to the laboratory. Filtered samples are then frozen in HDPE bottles until analyzed colorimetrically for nitrate and ammonium concentrations on an 8000 Series Lachat Flow Injection Analyzer (Hach Corp., Loveland, CO).

Nitrogen outputs were measured weekly/monthly using tension lysimetry. Tension lysimeters (Soil Moisture Equipment Corporation, Santa Barbara, CA) were installed in fall 2004 to a depth of 50 cm in three locations (adjacent to throughfall collectors) at the same eight sites. Lysimeters consist of a PVC tube with a porous, ceramic cup at one end and a cap with open tubing on the other end. A hand pump is used to pump 70 centibars (similar to the amount of pressure exerted by a plant root) of vacuum into the lysimeter through the open tubing a week prior to sampling. Water flows from the soil through the ceramic cup and is stored in the PVC pipe. Samples are pumped from the lysimeter directly into a glass scintillation vial. Samples are transported on ice and filtered immediately upon return to the laboratory same as above. Samples are also stored frozen in HDPE bottles until analyzed colorimetrically for nitrate and ammonium concentrations on the Lachat.

Principal Findings and Significance

Tension lysimeters were purchased last summer and installed in nine sites last fall. They require four to six months of fairly regular rains to equilibrate and establish good contact with the soil. The lysimeters equilibrated over the fall and winter. I began sampling the lysimeters weekly at the end of April. At the beginning of June, I initiated monthly sampling since there is not enough leachate produced for weekly collections, particularly during the summer when rain events are less frequent and abundant vegetation removes a significant portion of leachate before it can be collected. I intend to maintain a monthly collection schedule for a full year. I will also sample weekly during one month each season to capture variation on a finer temporal scale. Other funding sources have been obtained to extend this work.

Throughfall collectors were installed at eight sites at the end of April to coincide with the initiation of lysimeter collection. It was not possible to sample more than eight sites when following a weekly sampling schedule. The ninth site can be instrumented with throughfall collectors now that a monthly sampling schedule has been established.

Since sampling has just commenced, I do not yet have results to present in this report. Samples will be analyzed for nitrate and ammonium concentrations within several weeks of collection. A full data set will not be available for analysis until next summer. I expect nitrogen concentrations in throughfall to be higher in more urban sites (i.e., sites with higher road densities and higher numbers of road crossings over streams) than less urban sites. I will calculate these urban indicators using GIS data obtained through the Center for Remote Sensing and Spatial Analysis at Rutgers. I also expect nitrogen concentrations in leachate to be higher in sites with higher thoughfall so that these data sets should show some correlation. I also expect to find more nitrogen in leachate from sites with dry/flashy hydrology compared with sites with more normal hydrology. I have already collected two to three years of hydrology data at all of these sites. Lastly I expect to find more nitrogen in leachate from sites with higher rates of nitrogen mineralization and nitrification than compared with sites with lower nitrogen cycling rates. I have already collected one year's worth of nitrogen cycling data to use for this comparison.