ANNUAL *REPORT*
FEBRUARY 2000

William J Showers
Associate Professor
Dept. of Marine, Earth & Atmospheric Sciences

Isotopic Tracers of Nutrient Sources to the Neuse River Basin Surface Waters

The concentration and the isotopic composition of nutrients in surface waters have been monitored for 1 to 3 years at 17 stations in the Neuse River Basin. New analytical methods have been developed to rapidly process isotopic samples for the analysis of multiple isotopes. The isotopic composition of river nitrate varies with river discharge. During low discharge periods the isotopic composition of river nitrate is similar to point source nitrate. When river discharge rises, the isotopic composition of river nitrate decreases, indicating non-point source nitrogen is dominated by fertilizer runoff. Most of the nitrogen flux to our estuaries and sounds occurs during high discharge. One of the important results of the isotope tracer program is that the character of this high discharge nutrient loading has changed during the last decade.

Over the past 10 years the isotopic composition of the high discharge end member at the head of the estuary (Streets Ferry Bridge) has become more positive. ^{15}N, the heavier isotope of nitrogen is concentrated in waste, both human and animal. Stations in the upper and middle parts of the basin were monitored to determine where this heavier nitrogen was entering the river during high flow periods. The upper Neuse Basin stations do not show this positive shift during high river discharge, indicating municipal sewage from the upper basin is not the cause. The middle Neuse Basin stations do show the positive shift during high river flow conditions. The central sub-basin is also an area of groundwater recharge and an area of increased density of animal populations, primarily swine. Migration of this animal waste nitrogen is controlled by the residence time of groundwater in the recharge areas. Preliminary data indicates that groundwater residence time in these areas is on the order of 5-30 years. The residence time and groundwater pathways are not well understood, yet this information is crucial for policy changes that will protect our rivers, lakes, and streams. The preliminary data suggests that any changes in land use will not be reflected in surface water chemistry for 5 to 15 years.

More work is clearly required to understand these changes in groundwater chemistry. A collaborative project studying groundwater has been started with the USGS. Monitoring the effect of large animal waste spills indicates that wetlands are extremely efficient at adsorbing excess nitrogen from surface waters. A GIS analysis of the Cape Fear, Neuse River Basin and Tar Pam River

Basins show that the location of animal waste lagoons in the Neuse have the highest overlap with groundwater recharge/discharge areas. In the Neuse there are only 650 animal waste lagoons, but 30% of these lagoons are located in groundwater discharge areas, as opposed to 5% of the 1350 lagoons in the Cape Fear and 12% of the 200 lagoons located in the Tar Pamlico River Basin. Watersheds that have an overlap of dense animal populations with groundwater recharge/discharge areas will be compared to watersheds that do not have an overlap during the RiverNet program (see below).

Long term nutrient fluxes in the Neuse Basin are related to El Nino/La Nina (ENSO) climate cycles, because most of the loading comes from these non-point sources that are active during high discharge periods. It has been established that these cycles control precipitation in North Carolina (we currently are in a La Nina cycle). Increased precipitation leads to increased river discharge and increased nutrient fluxes. Hurricanes during non-ENSO years can also have a large and variable impact on river discharge and nutrients. From 1950 to 1970 the cooler La Nina periods had the largest impact on river discharge. After the 1970's, the warmer El Nino periods have had the largest impact. Since 1972 the "Super El Ninos" (1972, 1982, 1997) have the largest impact of all other climate variations. Number of fish kills is related to changes in river nutrient flux to the estuary. When hurricanes and events occur back to back, the most severe water quality events occur.

Recommendations:

- Wetlands preservation and reconstruction is important for surface water protection from excess nutrients in addition to riparian buffers.

- Animal waste lagoon buyout/relocation plans should consider groundwater recharge areas as well as location of flood plains.

- Nutrient changes in surface water will vary with land use changes modulated by groundwater residence time and ENSO cycle precipitation changes. Long term nutrient monitoring is important to understand these changes on a watershed scale.

- Point source reductions are a viable approach to immediately reduce nutrient river loads over the short term. Biological dentirification system greatly reduces the point source load to our rivers.

Isotopic Tracers of the Source of Atmospheric Deposition of Ammonium in Rainfall

Multi-year wet deposition records have been analyzed for 6 stations at Raleigh, Goldsboro, Kinston, New Bern, Morehead City, and the Eastern Farm Site in Sampson County near Faison. Studies have shown that ^{14}N, the lighter isotope of nitrogen, is concentrated in the ammonia that is volatilized from waste lagoons. Rural areas have higher concentrations of NH_4 in rainfall, while urban areas have higher concentrations of NO_x. Atmospheric deposition of nitrogen (ADN) rates are heaviest in the central Neuse basin on an annual basis. In the central Neuse basin, highest rates of ADN occur in the late summer and early fall when temperatures are highest. Highest rates of ADN ammonium at the farm site also occur in the late summer and early fall period. The isotopic composition of rainfall ammonium is different from the urban areas (Raleigh) and the rural areas (Sampson County) allowing source differences to be determined. The rainfall ammonium isotopic composition indicates that animal waste ammonium affects the central Neuse basin during the entire year, and is deposited in the coastal areas periodically during the late summer and early fall period.

Recommendations:

- Expand ADN monitoring network to find the maximum extent of the effects of the summer/fall animal waste NH_3 emissions

- Monitor organic nitrogen as well as inorganic forms

- Alternative technologies may be able to reduce emission rates of ammonia by increasing emission rates of molecular nitrogen using biological denitrification systems. When these systems are in place monitor the rate and isotopic composition of volatilized ammonia.

RiverNet Monitoring Stations

Ion chemistry nutrient sensors (WS Ocean) have been compared to Ion Selective probes (Sonde). The ion chemistry nutrient sensors perform well at low nutrient concentrations found in most river surface waters. The ion selective probes were found to drift significantly at the low nutrient concentrations. Fixed monitoring stations with cell phone data transmission have been designed and the prototype built. The data transfer system using cell phones and an NT server has been tested and is in place. The first RiverNet monitoring station will be installed on the Neuse River at Seven Springs on the SR1731 Bridge during the week of February 28 to March 3, 2000. DOT Raleigh gave preliminary approval for this installation in January, 2000. DOT District 4 (Wayne County) review the application and required a bridge encroachment form to be submitted. After review by the staff engineer, approval was given on February 24, 2000.

Severe flooding in the basin after Hurricane Floyd and during the winter of 1999-2000 has prevented a fixed station deployment. A mobile monitoring station that can move up and down the river for spill detection has been constructed and been used to monitor Floyd flood waters. Data indicate that there was not a significant nutrient dilution in Floyd floodwaters in the river basin compared to Fran. The nitrogen associated with Floyd is also isotopically heavier than particulate nitrogen measured during in the river during Fran. This is the result the extensive flood damage during Floyd as opposed to wind damage during Fran. Fixed monitoring stations will be deployed when final DOT approval is given at sites recommended by the NC Water Quality Workgroup. Four more stations will be installed by June, 2000 and 10 stations will be installed during the following summer.

North Carolina Water Quality WorkGroup

Secretary Holman DENR and Chancellor Fox NCSU have appointed 15 members to the North Carolina Water Quality WorkGroup. One is from a federal agency (USGS), 8 associated with universities, 2 members are from DENR, and 2 members from other state or local government agencies and 2 are from private industry. The first meeting of this group took place on Nov 29, 1999 on the NCSU Centennial Campus. Since then there have been two more meetings and the fourth meeting is scheduled for March 7, 2000. Bill Kreutzberger CH2M HILL - Charlotte Office was elected Chairperson, Bill Showers Dept. MEAS NCSU was elected Vice Chairperson. Report of the NCWQW activities will be given to the Environmental Review Commission on Feb 24, 2000 as mandated in the legislative statute by Bill Kreutzberger.

.

Post-Floyd Contaminated Well Study

A GIS study is ongoing geo-locating private wells tested for bacterial contamination after flooding from Hurricane Floyd. This is a joint effort by the NCEM, DEH, NC-SLPH, DENR, NCSU Stable Isotope Lab and the NCSU Center for Earth Observation (GIS). Over 3000 tested wells have been geo-located to date, however an additional 5000 wells have been tested and require geo-location. Once wells are geo-located, the proximity of contaminated wells can be compared to flood extent, flood plain position, and proximity to animal waste lagoons. These proximity studies of fecal E. coli contaminated wells were null for proximity to swine waste lagoons, but were significant for proximity to the flood extent. This GIS effort will aid public and environmental health officials respond to the ongoing relief efforts in the flooded areas of eastern North Carolina.

For more and up-to-date information visit our RiverNet web site at:

http://rivernet.ncsu.edu/