Session J5: Nutrient Source Tracking using Multiple Lines of Evidence

Room C123
1:00 – 2:30 pm

0182
J5-1

Stable Isotope Mixing Models as a Tool for Tracking Sources of Water and Water Pollutants

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One goal of monitoring pollutants is to be able to trace the pollutant to its source. Here we review how mixing models using stable isotope information on water and water pollutants can help accomplish this goal. A number of elements exist in multiple stable (non-radioactive) isotopic forms that differ in the number of neutrons in the nucleus, *e.g.*, ^{14}N and ^{15}N, ^{16}O and ^{18}O, ^{2}H and ^{1}H. Various physical, chemical, and biological processes operate at slightly different rates on molecules containing these "light" and "heavy" isotopes because of their differences in mass. As a consequence, different materials (*e.g.*, fertilizer versus manure sources of nitrate, precipitation versus groundwater sources of water) often have distinctive isotopic compositions that can be useful for environmental tracking. One common use of this isotopic information is in quantifying the contributions of multiple sources to a mixture, using isotope data along with available chemical data. Given the isotopic compositions of the sources and the mixture, isotopic mixing models can be used to calculate the relative source proportions. We will review basic mixing models, how they work, and their further development over the last decade. To demonstrate how they may be helpful in water quality monitoring, we will discuss several examples of their application to quantifying water sources to stream flow and nutrient sources to nutrient loads in water bodies.

0282
J5-2

Combined Use of Stable Isotopes and Hydrologic Modeling to Better Understand Nutrient Dynamics in Highly Altered Systems

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Highly altered surface water systems present many challenges for water quality monitoring studies due to factors such as multiple potential nutrient and contaminant inputs, dynamic source water inputs, and changing flow regimes controlled by both natural and engineered conditions. Stable isotope analysis can provide additional information about sources and processes influencing nutrient distributions which cannot be obtained through concentration data alone. By combining concentration and stable isotope analyses with approaches such as mass balance calculations and hydrologic modeling, we can gain a much better understanding of nutrient dynamics throughout complex, highly altered systems. In order to demonstrate the applications of these techniques, we will focus on several related monitoring studies within the San Francisco Bay and Delta region, which provides an excellent example of a highly impacted and managed surface water system of critical environmental and economic importance. High nitrate concentrations within the San Joaquin River (SJR) fuel summer algal blooms, leading to areas of critically low dissolved oxygen. There are many potential nitrate sources within the SJR watershed, including agriculture, septic and wastewater treatment plant discharge, confined animal feeding operations, and high salt content soils on the SJR's west side. Using a combination of nitrate and water stable isotope analyses, combined with mass balance input calculations, we can distinguish between different sources of nitrate coming from the tributaries, identify river sections with significant inputs of unmeasured nutrients, and determine how biological processes such as algal uptake and denitrification alter nutrient distribution throughout the SJR.

The SJR and the Sacramento River provide the majority of freshwater to the Delta and north San Francisco Bay, and we have also used stable isotope measurements combined with hydrodynamic modeling to understand how the nutrients from these two rivers move through the Delta. Isotopic measurements and estimates of source water contributions derived from the DSM2-HYDRO hydrologic model demonstrate that mixing between SJR and Sacramento River water can occur as far as 30 miles upstream of the confluence within the SJR channel, and that SJR-derived nitrate only reaches the western Delta during periods of high flow.

0474
J5-3

Evaluation of Nutrient Concentrations, Sources, and Pathways in Three Urban Streams in Durham County, North Carolina

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In 2010, the North Carolina Environmental Management Commission adopted nutrient-management strategies for the Falls Lake and Jordan Lake reservoirs that call for comprehensive controls to reduce nitrogen and phosphorus loads from sources in the watershed, including urban stormwater, wastewater, and agriculture. The City of Durham Public Works Department Stormwater Services Division is implementing best management practices (BMPs) for new and existing development to reduce nutrient inputs from stormwater. The small, urban watersheds that drain into Falls and Jordan Lakes typically have diverse sources of nutrients and other pollutants, embedded infrastructure, and limited available space, making effective BMPs complex and expensive to implement.

The US Geological Survey and the City of Durham are collaborating to evaluate current and historic nutrient concentration data at three low-order streams sites, two located within the upper Neuse River basin upstream from Falls Lake, and one located upstream from Jordan Lake in the Cape Fear River basin. Use of stable isotopes to characterize sources and transport of nitrogen in these streams was evaluated as a tool for optimizing design and cost effectiveness of BMPs for improving water quality. Results will be transferable to other low-order urban streams of the North Carolina Piedmont Physiographic Province. Six months of preliminary data with analyses of transport pathways and nitrogen sources will be presented with discussion focusing on the benefits of using stable isotope analyses.

0548
J5-4

Lessons Learned From 20+ Years of Piggybacking Nutrient and Organic Matter Studies onto Large-Scale Monitoring Programs

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The main thrust of our research for 20+ years has been the tracing of nutrient sources and biogeochemical processes in aquatic systems using a multi-isotope approach. Many of these studies have been conducted at the regional to national scale by building on existing large-scale water, air, and ecological monitoring programs managed by federal and state agencies as part of large collaborative teams. Most studies include the use of nitrate-$\delta^{15}N$ and $\delta^{18}O$ to determine seasonal and spatial changes in nitrate sources, and the analysis of seston for $\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$, C:N, and C:S to trace sources of organics, the linkage between nutrients and algae, and biogeochemical processes; and analysis of water-$\delta^{18}O$ and $\delta^{2}H$ to trace water sources.

We have found that isotopes have a novel ability to integrate environmental variability such that major natural patterns emerge and can be meaningfully interpreted. For example, locations exhibiting unusually high rates of biogeochemical cycling or elevated pollution levels usually have distinctive isotopic compositions that are suggestive or diagnostic of the reactions and pollution sources. Isotopic compositions may change even when concentrations do not. Hence, isotopes facilitate the identification of hot spots and moments that otherwise would not be apparent, thereby providing a valuable complement to standard chemical and hydrological mass balance methods. Although fixed-site sampling is the norm in watershed studies, we have found that isotope and chemical data collected during longitudinal transects of rivers have been more useful in providing new insights – and often in contradicting or enhancing previous theories about sources and processes. Synoptic sampling is another powerful tool for regional and national assessments of ecological impacts.

This presentation will describe the “state of the science” regarding the ability of isotopes to distinguish anthropogenic impacts and nutrient cycling dynamics at large spatial scales, provide suggestions for successful pilot studies, and propose guidelines for future monitoring in biologically active and human-impacted rivers. As more studies demonstrate the value of isotopes in large-scale monitoring programs, we hope to see these analyses eventually incorporated into routine monitoring plans.