Using Stable Isotopes to Link Hydrology to Nitrogen Biogeochemistry Over Multiple Space and Timescales

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Nitrogen is a critical element which limits the primary production in a wide variety of terrestrial and aquatic ecosystems. Anthropogenic inputs of nitrogen in recent years at the global, watershed and local scales have impaired drinking water supplies and lead to eutrophication of aquatic systems. A more complete understanding of nitrogen cycling, retention and fate in the environment is needed. This is important knowledge to serve as a basis for sustainable COE water management practices and wetland/riparian zone restoration activities in watersheds. Natural ^{2}H and ^{18}O isotopic signals in water provide information on water origin, mixing history, water balance residence times, surface-groundwater exchange and renewal rates, evaporation and transpiration that is being used with measures of volumetric flux and incorporated into watershed-scale models used to relate land use changes and climate to progressive changes in basin hydrology. Natural ^{15}N and ^{18}O isotopic abundances are being used to determine the sources of nitrate in watersheds and to infer potential sinks. Spiking of samples/systems with heavy N labeled tracers and analysis by stable isotopic ratio mass spectrometry provides a direct means to measure all reactions in the critical biogeochemical nitrogen cycle and produce rate data that can be directly incorporated into watershed models. This approach has been recently used to show that the anaerobic ammonium oxidation pathway may account for over 50% of denitrification globally. Perhaps the greatest advantage of using stable isotopes is that they provide a means to link plant and animal ecophysiology and community dynamics to nitrogen biogeochemistry in the context of variable hydrological drivers. Quantitative analysis of nitrogen cycle dynamics on the interface between purely terrestrial and purely aquatic portions of the watershed, the so-called riparian and wetland zones, is needed to accurately model watershed scale dynamics of nitrogen. These zones are poorly studied and have high but very variable potential for denitrification. They are an important but yet unknown variable in the N export in streams and rivers.