General Patterns of Nitrogen Cycling in the Upper Mississippi River (UMR) and Floodplain

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Current loads of TN in Navigation Pool 8 of the UMR range from ~15 $x10^3$ t · $month^{-1}$ (spr) to ~1 $x10^3$ t · $month^{-1}$ (winter), with NO_3^- making up 90-95 % of the total load. A three year study to evaluate N-cycling processes and budget in Navigation Pool 8 (2000 - 2002) showed flood plain backwaters and impounded areas with highest rates of denitrification potential (10.9 and 7.6 ug N · cm^{-2} · hr^{-1}, respectively); side and main channels exhibiting the lowest rates (2.2 and 1.6 ug N · cm^{-2} · hr^{-1}, respectively). Ambient rates of denitrification were similar across all habitats (~0.18 ug N · cm^{-2} · hr^{-1}). Nitrification rates were also highest in backwaters and impounded areas (1.1 and 1.4 ug N · cm^{-2} · hr^{-1}, respectively), and lowest in main and side channels (0.3 and 0.6 ug N · cm^{-2} · hr^{-1}, respectively). We estimate denitrification removes ~ 6900 tons of nitrate-N annually from Pool 8. Relative to the total load, this represents ~ 7 % of the total NO_3^- load. Much of the NO_3^- removal is offset by nitrification, which contributes ~7 tons N/yr in navigation Pool 8.

Backwaters and impounded areas are generally the most biogeochemically active areas of the flood plain river system due to high carbon sediments and relatively long hydraulic retention times. Nitrate processing, however, is limited by nitrate delivery from nitrate-rich main channels waters, while nitrification is often limited by low sediment oxygen. These conditions result in a build-up of plant-derived organic N and high sediment ammonium concentrations. Coupled nitrification-denitrification likely plays an important role in backwater N-cycling, particularly in periods of low flow, when water column NO_3^- concentrations in backwaters are extremely low. Connectivity between channels and backwaters - especially during floods - to a large extent controls rates of nitrate delivery and denitrification. Connectivity likely also effects oxygen dynamics at the sediment-water interface and the resultant effect on nitrification. Summer floods are the most potent driver of nitrate-denitrification dynamics because of the combination of substrate delivery (nitrate) and optimal thermal conditions. Winter N-dynamics, particularly in backwaters, are controlled by variation in oxygen concentration, which in turn is controlled by light and algal dynamics. Elevated nitrification-derived nitrate in winter can drive high denitrification rates even in periods of low water temperature.

System-wide estimates of N flux - derived from geospatial modeling and extrapolation of N-cycling processes in Pools 4, 8, 19, and 26, show that a total of ~ 9 % of the total N load is removed via a balance of biogeochemical processes. Increased hydrologic retention times and exposure of nitrate load to sediment carbon would result in increased N load removal.