

Rapid precipitation and dissolution of nanoscale carbonates implies rapid cycling of Zn between solids and solution. In a second microbially-mediated process, aggregates of nanometer-scale Fe-oxhydroxides form in the oxidized portions of the redox gradient. Ferrihydrite, ferroxihite, and goethite develop in association with iron-oxidizing microorganisms such as Gallionella and Leptothrix spp.. The abundant nanophase FeOOH particles contain a few weight percent Zn, thus concentrate Zn by at least four orders of magnitude relative to solution. Cells and iron oxhydroxides accumulate in thick layers on tunnel floors. As the organic compounds are consumed by microorganisms, biofilms become anoxic. Continued organic respiration by iron-reducing bacteria leads to dissolution of FeOOH and release of associated Zn. Under reducing conditions, Zn is sequestered by a third microbially-mediated process occurring in pale colored biofilms dominated by relatively aerotolerant sulfate-reducing bacteria of the family Desulfobacteriaceae. The biofilms contain abundant 0.1 to 10 m-diameter, spherical aggregates of nanophase sphalerite, ZnS. Sulfate reduction and subsequent precipitation of ZnS concentrates Zn by eight orders of magnitude compared to associated groundwater.

B11E-11 1120h INVITED

Microfossils and Secondary Mineralization in Columbia River Basalts

James P McKinley¹ (509+375-6841; james.mckinley@pnl.gov)

Todd O Stevens¹ (509+373-0891; todd.stevens@pnl.gov)

Frances Westall² (281+483-6091; frances.westall1@jsc.nasa.gov)

¹Pacific Northwest National Laboratory, PO Box 999, Richland, WA 99352, United States

²NASA, SN2-NASA-Johnson Space Center, Houston, TX 77058, United States

Groundwater within Columbia River Basalts resides in part in fractures within massive flows. The groundwater sulfate concentration is an indicator of the relative abundance of methanogens and sulfate reducers. Secondary minerals are abundant in fractures and are associated with microbes grown from these waters; in vitro experiments using basalt and unfiltered groundwater resulted in the formation of secondary minerals on surface-adherent microbial colonies. We subsampled basalt cores containing fractures that were healed by the formation of secondary minerals, and examined the fractures for microfossils that would be analogous to the mineralization observed in laboratory experiments. Secondary minerals near and within fractures contained numerous objects resembling bacteria, commonly rods or ellipses, but also included cocci and diplococci forms, vibrioids and club-shaped rods, and associated pairs of objects that suggested cellular division by binary fission. SEM examination of these fossils showed them to consist of minerals and kerogen. Secondary minerals associated with, enclosing, and comprising microfossils included iron oxhydroxides, apatite, sulfides, and smectites containing ferrous iron. The association of microfossils with minerals formed in reducing environments suggested an ancient ecosystem dominated by sulfate reducing and other anaerobic bacteria. The paleoenvironment was thus similar to the environment in place today.

B11E-12 1135h

Biomass Determination of Silicate Surfaces in Groundwater Systems

Jennifer Roberts Rogers¹ ((512) 471-5413; jroberts@mail.utexas.edu)

Philip C Bennett¹ ((512)471-3587; pbennett@mail.utexas.edu)

¹Jennifer Roberts Rogers, University of Texas at Austin Department of Geological Sciences, Austin, TX 78712, United States

In some environments relatively small numbers of microorganisms (10 e5/m2) are responsible for rapid mineral weathering by merely attaching to the mineral surface. Previous research has shown that organisms create a reactive microenvironment of metabolic byproducts at the mineral surface that dissolve the mineral in a localized area around the organism. The natural abundance of microbial populations on mineral surfaces can be characterized using a variety of techniques. The methods used in this study include SEM observation, most probable number determination (MPN), direct counts using DAPI staining, and total lipid biomass determination. These methods were useful indicators of biomass but produced very different results. Attachment and colonization of mineral surfaces was investigated using in situ microcosms at the USGS Toxics site near Bemidji, MN. The relationship between microorganisms and mineral surfaces

was studied in the aquifer by introducing clean mineral chips and letting the naturally occurring microorganisms in the groundwater interact with them. Chips were retrieved after 3-12 months and splits were used for each method. Chips were imaged using SEM and analyzed with MPN using media specific for iron reducers, facultative anaerobes and fermenters, and total methanogens. Direct counts were done by dislodging organisms from the mineral surface then collecting them onto black iraguli filters, which were stained with DAPI and imaged on a scanning laser confocal microscope. Total lipid biomass, MPN, and direct counting methods all resulted in higher cell counts than observed with SEM. The SEM observations only account for permanent attachment because of the fixation process used, while the other methods account for all organisms both loosely attached and permanently attached. MPN differs further, because it is a culturing method that selects for culturable organisms in specific media. Non-viable or spored organisms may also be responsible for the variations. While the spores may not be viewed with SEM at the scale of imaging used, they may be revived and cultured in MPN media. In contrast, some of the SEM-imaged organisms may not be culturable. While all of these techniques are valuable in characterizing surface biomass the numbers produced may represent only specific fractions of the attached microbial population, while others may include all organisms, including non-viable and spored organisms.

B11F MC: 122 Monday 0830h

Nitrogen-Cycling Processes in Rivers and Streams (joint with H)

Presiding: R L Smith, U.S. Geological Survey; F J Triska, U.S. Geological Survey

B11F-01 0830h

Nitrogen Cycling in a Desert Stream Ecosystem: Influences of Sandbar Hydrology on the Distribution of Hotspots for Nitrogen Retention by Periphyton

Julia Curro Henry¹ (1-480-965-6478; julia.henry@asu.edu)

Stuart G. Fisher¹ (1-480-965-6478; s.fisher@asu.edu)

¹Department of Biology, Arizona State University, Tempe, AZ 85287, United States

Distinct spatial patterns of different types of periphyton are associated with coarse alluvial sandbars in Sycamore Creek, a nitrogen limited desert stream near Phoenix, Arizona. This study was designed to answer the question, Why are periphyton communities at some sandbar edges dominated by nitrogen fixing cyanobacteria while others are dominated by non-fixing green algae? The hypothesis that green algae may grow preferentially at locations where high nitrate water outflows from sandbars while cyanobacteria, which can obtain supplementary nitrogen from the atmosphere, inhabit influent sandbar edges with low nitrate concentrations, was tested several ways. We measured hydrologic and nutrient conditions at 20 sandbar edges with different periphyton types. We then quantitatively sampled periphyton biovolume (involving microscope identification, counting, and measurement of individual cells) at 12 inwelling and outwelling edges with different nitrate concentrations. We tested the hypothesis experimentally, by transplanting green algae to cyanobacteria edges and vice versa. We also tested the hypothesis using a natural experiment, by monitoring periphyton biovolume sandbar edges over time as outwelling conditions and elevated nitrate concentrations decreased. Percent retention of outwelling nitrate by resident algae was also measured at 10 outwelling edges. Reciprocally, transplanted algae and cyanobacteria both experienced a 30% reduction in biomass while controls generally increased in biomass. The success of transplants depended on hydrologic conditions at edges. Eight of nine green algal sandbar edges were found to be outwelling edges with elevated nitrate and all eleven cyanobacteria edges were inwelling edges. Abundance of certain green algae was positively correlated with nitrate availability at sandbar edges while the abundance of cyanobacteria was negatively related to nitrate availability. Green algal biovolume was greater than cyanobacteria biovolume at a time when sandbars were sources of nitrate, but the opposite was true 3 weeks later when nitrate was no longer available at those edges. Green algae retained between 63 and 97 percent of outwelling nitrate depending inversely on outwelling rate. Sandbar hydrology strongly influences the distribution of n-fixing and non-fixing periphyton and retention of outwelling nitrate at sandbar edges. Clearly, sandbars are important features of desert stream channels as they may influence whole stream nitrogen retention by restricting nitrogen fixation and stimulating retention at outwelling edges.

B11F-02 0845h

65279; Nitrogen Dynamics and Processes in the Upper Mississippi River, A Large Temperate Floodplain River.

William Richardson¹ (608-781-6231;

william-richardson@usgs.gov); David Soballe¹ (608-781-6216; david.soballe@usgs.gov); Eric Strauss¹ (608-781-6282; eric.strauss@usgs.gov); Lynn Bartsch¹ (608-781-6286; lynn_bartsch@usgs.gov); Lori Rabuck¹ (608-781-6268; lori_rabuck@usgs.gov); Emy Monroe¹ (608-781-6262; emy.monroe@usgs.gov); Timothy Michel¹ (608-781-2275; timothy_michel@usgs.gov)

¹U.S. Geological Survey, Upper Midwest Environmental Sciences Center 2630 Fanta Reed Road, La Crosse, WI 54603, United States

#65279; Nitrogen from the Mississippi River has been implicated in ecological declines in the Gulf of Mexico. Nitrate, in particular, appears to pass conservatively from the Upper Mississippi River to the Gulf of Mexico. While the Upper Mississippi River basin contains large expanses of riparian wetlands and vegetated backwater lakes - hypothetically capable of supporting substantial denitrification of nitrate - the potential for the Upper Mississippi River and floodplain system to process nitrogen is poorly understood and largely unquantified. In a multi-scale approach, we performed a mass-balance and reach-specific analysis (27km reach of the Mississippi River, near La Crosse, Wisconsin) of nitrogen processes to determine source-sink dynamics of nitrogen in pooled reaches of the Upper Mississippi River. Process studies were initiated in October 1999; 60 sites were sampled for sediment denitrification, total organic carbon, porewater and exchangeable NH_4^+ and NO_3^- ; we measured NH_4^+ and NO_3^- in the overlying water.

Because mass-balance analysis indicated that total nitrogen inputs from tributaries are not substantially altered during transport in the river system we examined smaller-scale nitrogen dynamics. Using semi-empirical models we evaluated seasonal relationships among nitrogen concentrations, water exchange, and biological transformation in short (about 30-50 km) river-floodplain segments. At this scale we used GIS technology to combine (1) detailed morphometry, (2) output from a two-dimensional flow model, and (3) limnological monitoring data (1993-99). We found nitrate concentrations were highest during spring flooding and lowest in fall (October-November). Nitrate concentrations were generally lower in off-channel areas than in the main channel and decreased with increased isolation from main channel sources. Mass-balance indicated greatest biological effects on nitrogen flux during flood, but biological influences on nitrogen concentration were most apparent at low flow.

Process studies indicated isolated backwaters tended to have the lowest denitrification rates (14.9 mg N/m²/d + 4.38 SE), lowest surface water NO_3^- , and highest sediment carbon and NH_4^+ concentrations; conversely, sediments near large channels tended to have the highest rates of denitrification (43.0 mg N/m²/d + 9.3 SE) and lower sediment carbon. Monitoring data supports our contention that much of the area with the highest denitrification potential is hydrologically isolated from the NO_3^- source. Denitrification across the entire reach would likely increase by increasing connectivity between the main channel and backwaters during summer and fall.

B11F-03 0900h

Spatial and Temporal Patterns and Limiting Factors of Ammonia Oxidation in the Upper Mississippi River

Eric A. Strauss¹ (1-608-783-6282; eric.strauss@usgs.gov)

Lynn A. Bartsch¹

Julie A. Heinz¹

William B. Richardson¹

¹Upper Midwest Environmental Sciences Center, U.S. Geological Survey, 2630 Fanta Reed Rd., La Crosse, WI 54603, United States

An assessment of patterns and controls of nitrogen cycling processes in large rivers is of paramount importance because: 1) the dearth of information currently available; and 2) the deleterious effect of high nitrogen load to coastal marine ecosystems (e.g., hypoxia). Nitrification is one nitrogen cycle process that may be of particular importance because of its end product, nitrate. Nitrate availability often limits denitrification in areas where activity could potentially be very high (e.g., backwater lakes and riparian wetlands

with organic-rich sediment), suggesting the importance coupled nitrification/denitrification. In this study, we utilized mensurative field sampling and experimental studies to explore the spatial and temporal patterns associated with nitrification in the Upper Mississippi River. We measured sediment nitrification in the laboratory using the nitrapyrin method in May 2000 and again in August 2000 on samples collected from 61 locations in Pool 8 of the Mississippi River, near La Crosse, WI. Nitrification was generally low ($< 1 \mu\text{g N cm}^{-2} \text{ hr}^{-1}$) in or near the main channel during both sampling events. In off-channel and backwater areas nitrification was highly variable ($0 - 7 \mu\text{g N cm}^{-2} \text{ hr}^{-1}$) and was dependent on the chemical and physical parameters of the sediment and overlying water. Pool-wide nitrification rates were slightly higher in August 2000 (mean rate = $1.7 \mu\text{g N cm}^{-2} \text{ hr}^{-1}$) compared to May 2000 (mean rate = $1.3 \mu\text{g N cm}^{-2} \text{ hr}^{-1}$), with the difference being marginally significant ($P = 0.09$). In addition to the general sampling, fine scale sampling was conducted in July 2000 at two sites (organic-rich silt sediment vs. organic-poor sand sediment) to determine vertical stratification of nitrification (1 cm resolution) and oxygen availability (1 mm resolution measured with an oxygen microprobe) within the upper 5 cm of sediment. In the organic-poor sediment, nitrification was highest in the uppermost 1 cm ($0.412 \mu\text{g N cm}^{-2} \text{ hr}^{-1}$) and declined with depth to 3 cm; similarly, oxygen availability was greatest at the sediment-water interface (80% saturation) and declined to 0% saturation by 6 mm. In the organic-rich sediment, both nitrification and oxygen were relatively low and did not differ throughout the sediment profile. Finally, a manipulative experiment was conducted to determine if ammonia availability was limiting nitrification at 3 sites (the two sites mentioned previously plus a moderately organic sand sediment). None of the 3 sites responded significantly ($P > 0.05$) to the ammonia addition (2 mg N L^{-1} as NH_4Cl). These results suggest that nitrification in the Upper Mississippi River is not limited by ammonia but rather oxygen penetration into sediments, thus dependence of denitrification on nitrate derived from nitrification (i.e., coupled nitrification/denitrification) is likely only under conditions when sufficient oxygen is present in the sediments.

B11F-04 0915h

High-flow and Low-flow Nutrient Distribution in Navigation Pool 8, Upper Mississippi River: Implications for Nitrate Processing by Channel Sediments

Frank J. Triska¹ (650-329-4437; ftriska@usgs.gov); Alan P. Jackman² (530-752-8777; ajackman@usgs.gov); Ean Warren¹ (650-329-4554; ewarren@usgs.gov); John H. Duff¹ (650-329-4319; johnduff@usgs.gov); Edward M. Godsy¹ (650-329-4504; emgodsy@usgs.gov); Richard W. Sheibley² (530-752-8777)

¹U.S. Geological Survey, 345 Middlefield Rd, Menlo Park, CA 94025, United States

²University of California, Dept of Chemical Engineering, Davis, CA 95616, United States

Agricultural nitrate runoff has been implicated as a cause of hypoxia in the Gulf of Mexico. Mass balance data from Pool 8, adjacent to La Crosse WI, indicates nitrate loss during transport at high spring flow, but not low summer flow. We investigated within pool distributions of NO_3^- , NH_4^+ , SRP, DO, and DOC in both seasons and conducted single point conservative tracer- NO_3^- or NO_3^- plus acetate amendments to determine likely sites of NO_3^- transformation and potential controlling factors. During spring floods, NO_3^- concentration in the main navigation channel was approximately 3.5 mg-N/L , but only $1.7\text{-}2.8 \text{ mg-N/L}$ in a connected, off-channel complex of islands and sloughs, indicating potential transformation. NO_3^- concentration was far lower at low flow and more evenly distributed between main channel and island complex (both approx. 0.9 mg-N/L). DOC at high flow was $8.4\text{-}9.9 \text{ mg/L}$ in the main channel and $10.3\text{-}10.7$ in the island complex. DIN was dominated by NO_3^- in surface water and NH_4^+ in pore water. DO was 6.5 to 9.4 mg/L in surface water but typically less than 1.0 mg/L in pore water indicating a reducing interstitial environment suitable for denitrification. Injected NO_3^- into the bed of an off-channel slough was depleted relative to a bromide tracer at three depths. (10, 20, 50 cm). Acetate stimulated NO_3^- depletion at all depths. We conclude that the capacity of Pool 8 to transform nitrate during transport depends on the capacity for hydrologic exchange of surface water into shallow channel sediments or inundation of organic carbon-rich zones during flooding, which increases surface area for microbial processing.

B11F-05 0930h

Nitrate Reduction in Upper Mississippi River Sediments Using In Situ Microcosms

Ean Warren¹ (1-650-329-4554; ewarren@usgs.gov)

E. Michael Godsy¹

John H. Duff¹

Frank J. Triska¹

Alan P. Jackman²

¹U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025, United States

²Univ. of California, Chem Engr & Mtrl Sci, Davis, CA 95616, United States

Each summer up to 18,000 km² of water area in the Gulf of Mexico experiences hypoxia, threatening an important commercial and recreational fishery. Nutrients from the Mississippi River, and the Upper Mississippi River in particular, have been implicated as the source of the hypoxia. An average of 1 million metric tons of nitrate flow into the Gulf each year. We initiated preliminary studies of surface and pore water chemistry and sediment microbial processes during low flow to determine potential impacts of the sediment microbial communities on dissolved nitrogen in river water. Differences in pore water and surface water chemistry indicate there is an oxic stream channel over anoxic sediments. Nitrate concentrations are significantly higher in surface water ($800 \mu\text{g N L}^{-1}$) than pore water ($150 \mu\text{g N L}^{-1}$). Nitrate reduction was observed in sediments overlain by either low (2 mg C L^{-1}) or high (9 mg C L^{-1}) dissolved organic carbon surface water and was further stimulated by the addition of acetate. Nitrate loss was accompanied by nitrite and nitrous oxide increases in the presence of acetylene, indicating active denitrification. The zero-order rate for nitrate reduction was higher in unamended high-organic carbon, low-nitrate sediments ($0.15 \text{ mg N L}^{-1} \text{ hr}^{-1}$) than in low-organic carbon, high-nitrate sediments ($0.05 \text{ mg N L}^{-1} \text{ hr}^{-1}$). In acetate-amended sediments, nitrate disappeared at a rate of $0.30 \text{ mg N L}^{-1} \text{ hr}^{-1}$ regardless of endogenous organic carbon content. Numbers of total aerobes, heterotrophic fermenters, and denitrifiers in main channel river water were similar to the respective numbers in the pore waters, with slightly more denitrifiers found in the high-nitrate pore water. Low numbers of iron-reducers and sulfate-reducers were found in water and on sediments in all locations. Methanogens were not present in concentrations greater than 2 per gram or per mL. Higher numbers of aerobes, heterotrophic fermenters, denitrifiers, and sulfate reducers were found on high-organic carbon sediments than on low-organic carbon sediments. Between high-dissolved organic carbon, low-nitrate sediments and low-dissolved organic carbon, high-nitrate sediments, differences in microbial numbers and nitrate reduction kinetics were found.

B11F-06 0945h

Denitrification Rates in Sediment Perfusion Cores From Pool 8, Upper Mississippi River Basin, La Crosse, WI

Richard W. Sheibley¹ (rwsheibley@ucdavis.edu);

Alan P. Jackman¹, John H. Duff², Frank J. Triska², E. M. Godsy², Ean Warren²

¹University of California, Davis, 1 Shields Ave. Department of Chemical Engineering, Davis, CA 95616, United States

²U.S. Geological Survey, Water Resources Division, Menlo Park, CA 94025, United States

Nitrate concentration in water of Pool 8, upper Mississippi River, was lower in side channels than in the main (navigation) channel, especially during spring when nitrate and discharge are highest. Sediment cores from one side channel site, Running Slough, were perfused to determine rates of DIN removal from river water. Cores, 2.3 cm diameter by 20 cm length, were inverted and perfused upward from the sediment/water interface at 1 mL/min using filtered surface water. Core sediment consisted of 94% sand, 5% silt, and 1% clay. Nitrate and DOC concentrations in surface water were 1 mg N/L and 10 mg C/L , respectively. Both oxic and anoxic water perfusions were undertaken, either untreated or amended with acetate and/or NO_3^- . Losses of NO_3^- between the inlet and outlet were negligible in cores perfused with oxic river water, even when amended with $10 \text{ mg NO}_3^- \text{-N/L}$. However, river water amended with both acetate (40 mg C/L) and NO_3^- (10 mg N/L) stimulated almost complete DIN removal. Acetate decreased by $10\text{-}20 \text{ mg C/L}$ during passage through the cores. Oxygen inhibited DIN removal except when carbon amendment induced anoxia.

The ratio of mg C consumed per mg N was 1.4. We attribute N losses to denitrification based on nitrous oxide evolution using the acetylene-block technique. The results of this study demonstrate that the rate of DIN processing in Pool 8 sediments may be limited by available organic carbon.

B11F-07 1030h

Hydrologic and Biogeochemical Controls on the Nitrogen and Carbon Stable Isotopic Compositions of Particulate Organic Matter in Large Rivers

Carol Kendall¹ (650-329-4576; ckendall@usgs.gov)

Steven R. Silva¹ (650-329-4558; srsilva@usgs.gov)

Valerie J. Kelly² (503-251-3244; vjkelly@usgs.gov)

¹U.S. Geological Survey, 345 Middlefield Road, MS 434, Menlo Park, CA 94025, United States

²U.S. Geological Survey, 10615 SE Cherry Blossom Drive, Portland, OR 97216, United States

Riverine particulate organic matter (POM) samples were collected bi-weekly to monthly from 40 NASQAN (National Stream Quality Accounting Network) sites in the Mississippi, Colorado, Rio Grande, and Columbia River Basins in 1996-97 and analyzed for carbon and nitrogen stable isotopic compositions, and C:N ratios. This large-scale study also incorporated ancillary chemical and hydrologic data to refine and extend the interpretations of POM sources beyond the source characterizations that could be done solely with isotopic and elemental ratios. The ancillary data were especially useful for differentiating between (1) seasonal changes in POM source materials and (2) the effects of local nutrient sources and in-stream biogeochemical processes.

A four-source mixing model (plankton, fresh terrestrial plant material, macrophytes, and soil organic material) was used to differentiate general sources of POM using $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, and C:N - and their correlations with chemical and hydrologic parameters. Average values of $\delta^{13}\text{C}$ and C:N for all four river systems indicate that plankton accounts for approximately half of POM. Although soil and macrophyte detritus have overlapping $\delta^{13}\text{C}$ and C:N values, their relative contributions can be distinguished at many sites by (1) the differences in $\delta^{15}\text{N}$ values, and (2) the strong correlations of $\delta^{13}\text{C}$ and C:N values with flow and flow-related parameters consistent with soil-derived materials in runoff. Periodic inputs of fresh terrestrial plant detritus at a few sites, principally on the Columbia and Ohio Rivers, are suggested by C:N ratios > 15 . Seasonal shifts in the $\delta^{13}\text{C}$ of POM when the C:N remains relatively constant probably indicate changes in the relative rates of photosynthesis and respiration. The $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ of POM also reflect the importance of internal and external sources of dissolved nitrogen and carbon, and the degree of in-stream processing. The $\delta^{15}\text{N}$ of POM provides valuable constraints for interpreting sources and cycling of nitrate in riverine systems.

B11F-08 1045h

In-Stream Nitrogen Loss in Nitrate-Contaminated Streams in the Upper Illinois River Basin

JK Bohlke¹ (703-648-6325; jkbohlke@usgs.gov); RL Smith²; MA Voytek³; JC Antweiler²; LK Smith³; AE Laursen⁴; RW Harvey¹

¹US Geological Survey, 431 National Center, Reston, VA 20192, United States

²US Geological Survey, 3215 Marine St., Boulder, CO 80303, United States

³U of Colorado, CIRES, Campus Box 216, Boulder, CO 80309, United States

⁴U of Notre Dame, CEST, 152A Fitzpatrick Hall, Notre Dame, IN 46556, United States

Streams draining agricultural watersheds commonly yield large nitrogen loads to coastal waters, but in-stream processes that modify those loads are poorly understood. Regional statistical models and limited local field studies indicate that large amounts of nitrogen could be removed from some stream systems as they flow from source areas to the coast, but reliable field tests of the processes and of their overall significance are needed. We are conducting a field-based study of nitrogen transport in the Iroquois River and one of its tributaries in the mid-west corn belt to provide quantitative information about in-stream nitrogen losses and to compare a variety of techniques, including: (1) A combination of Lagrangian (time-of-travel) and stationary time-series sampling of stream water for mass balance analysis, (2) Measurement of N_2 gas production (denitrification) rates in sediment cores with stream-water headspace containing $^{15}\text{NO}_3^-$ tracer, (3) Measurement and modeling of in situ excess N_2 gas in stream water to estimate denitrification rates, (4) In situ conservative tracer tests and sampling of pore

water to determine rates and depths of hyporheic exchange, and (5) Synoptic stream sampling to detect variations in microbial communities, primary productivity, and stable isotope fractionation related to nitrogen cycling. Preliminary results for low-to moderate flow conditions in two stream reaches (ranging from 0.3 to 20 m³/s) indicate significant rates of denitrification and assimilation, but with relatively little effect on net nitrogen loads, owing to the large fluxes of nitrate in these streams.

B11F-09 1100h

Nitrate, Nitrite and Ammonium Loads in Two Nitrate-Contaminated Streams in the Upper Illinois River Basin: a Lagrangian Study of the Net Effects of In-Stream Nitrogen Transformation Reactions

Ronald C Antweiler¹ (303 541 3047; antweil@usgs.gov)

Richard L Smith¹

Howard E Taylor¹

Johnkarl Bohlke²

Mary A Voytek²

¹U.S. Geological Survey, 3215 Marine St- Suite E-127, Boulder, CO 80303, United States

²U.S. Geological Survey, 431 National Center, Reston, VA 20192, United States

Two agriculturally-impacted streams in western Indiana-eastern Illinois, Sugar Creek and the Iroquois River, are sites of ongoing research to determine the rates and relative extent of in situ nitrogen transformations. Reaches of 24 kilometers along Sugar Creek and 13 kilometers along the Iroquois River were selected for Lagrangian sampling studies to determine how nitrogen species and nitrogen loads changed with transport along each reach. To date, each reach has been sampled three times: in June, 1999, flows were medium to high and ranged from 10-60 cubic feet per second (cfs) in Sugar Creek and 200-290 cfs in the Iroquois River; September, 1999 was characterized by low flows varying between 1-6 cfs in Sugar Creek and 18-25 cfs in the Iroquois River; in May, 2000, flows were high and ranged from 14-73 cfs in Sugar Creek and 600-700 cfs in the Iroquois River. During the May and June sampling trips, 90-95% of the dissolved nitrogen was nitrate in the Iroquois River, and over 95% was nitrate in Sugar Creek; however, during the September trip, these quantities markedly decreased to 50-80%. In each case, the majority of the remainder was organic nitrogen. For both reaches during the medium to high flow periods, there was no evidence that nitrate loads were appreciably changing except in response to discharge. However, during the low flow period (September), nitrate loads decreased whereas discharge remained relatively constant, indicating that nitrate was being removed (or transformed) at this time. Nitrite, ammonium and dissolved organic (Kjeldahl) nitrogen loads did not exhibit any systematic changes: at times they increased relative to discharge, whereas at other times they decreased relative to discharge. These findings indicate that although nitrogen cycling processes are undoubtedly occurring in these streams, the overall quantity of nitrate being carried was largely unaffected by these reactions except at periods of low flow.

B11F-10 1115h

Dissolved Organic Nitrogen in Five Forested Headwater Streams in Pennsylvania

Bryan R Swistock¹ (814-863-0194; brs@psu.edu)

David R DeWalle¹ (814-863-0291; drdewalle@psu.edu)

William E Sharpe¹ (814-863-0291; wes@psu.edu)

¹Environmental Resources Research Institute and School of Forest Resources The Pennsylvania State University, Land and Water Research Building, University Park, PA 16802, United States

Recent interest in nitrogen cycling and export from forested watersheds has prompted study of the importance and variations in dissolved organic nitrogen (DON) in stream water. DON concentrations were measured monthly in five low alkalinity headwater streams as part of the USEPA funded Long Term Monitoring Project from January 1997 through June 2000. Samples were analyzed for nitrate, ammonia, total dissolved nitrogen (TDN) and dissolved organic carbon (DOC) and DON was calculated as the difference between TDN and the inorganic nitrogen species. Monthly sampling over three and a half years allowed for comparison of DON fluctuations among seasons and over a range of flow conditions. DON concentrations were similar among the five streams with means ranging from 0.04 to 0.07

mg/L. DON concentrations were correlated poorly with both nitrate and ammonia on all five streams. Higher DON concentrations usually occurred during high flows in late winter and early spring. The highest DON concentrations were observed during early 2000 immediately following a severe prolonged drought in 1999. The molar ratio of DOC to DON was highly variable but averaged 30 to 60 in these streams. DON contributed an average of 10 to 30 percent of the total dissolved nitrogen, but its importance exceeded 50 percent during spring high flow periods on some streams. DON is an important component of dissolved nitrogen export in streams on forested catchments in this region which should be included in future long-term monitoring programs.

B11F-11 1130h

Nitrous Oxide (N₂O) Emissions From Drainage Waters in an Intensively Farmed, Subtropical Valley

John A Harrison¹ ((650)725-5119; harrison@pangea.stanford.edu)

Pamela A Matson¹ (matson@pangea.stanford.edu)

¹Stanford University, Department of Geological and Environmental Sciences, Stanford, CA 94305, United States

Though agricultural runoff is thought to constitute a globally important source of nitrous oxide (N₂O), production and emission of N₂O in these systems is poorly understood, especially in non-temperate regions where the most rapid agricultural intensification is occurring. We measured the rates and patterns of N₂O emissions from freshwater drainage systems receiving agricultural and mixed agricultural/urban drainage water from the intensively farmed Yaqui Valley of Sonora, Mexico. N₂O emissions in both pure agriculture and mixed urban/agriculture drainage systems were high (means: 9.56-166.53 ng N₂O-N cm² hr⁻¹) with N₂O emissions increasing as much as 379% following a valley-wide fertilization/irrigation event. N₂O fluxes were not significantly correlated with nitrate or ammonium concentrations but were correlated, though weakly, with dissolved organic carbon and temperature (P=0.0746 0.0847 respectively). These results suggest that denitrification and N₂O production in these systems are limited by carbon availability rather than nitrogen availability. Laboratory experiments supported this hypothesis. Our results show that N₂O emissions from drainage waters in the Yaqui Valley are high, that rates of N₂O emission from surface drainage waters are tightly linked to upland development and management practices, and that carbon, not inorganic nitrogen, likely limits N₂O production in this system.

B11F-12 1145h

Spatio-temporal Variability of Stream-Nitrate Levels in a Small, Agricultural "Hill-Land" Catchment in East-central Pennsylvania

Christopher W Shade¹ (217-352-5577; cwshade@uiuc.edu)

Carl O. Moses² (com0@lehigh.edu)

Robert J.M. Hudson¹ (217-333-7641; rjhudson@uiuc.edu)

¹Dept. of Natural Resources Environmental Sciences University of Illinois, Urbana-Champaign, Turner Hall, Champaign, IL 61820, United States

²Dept. of Earth Environmental Sciences Lehigh University, 31 Williams Dr., Bethlehem, PA 18015, United States

The dynamics of biogeochemical processes in the riparian zone cause spatio-temporal variations in stream nitrate levels that are readily observable at the catchment scale. Much current research effort is aimed at simultaneously examining the temporal variables of season and flow and the spatial variables of land use, geology, and the characteristics of the near-stream/riparian zone. This paper reports on water chemistry data gathered at several sites across a small, medium-relief agricultural catchment in East-central Pennsylvania and their analysis using semi-empirical models that link these observations to spatial data generated using GIS. The chemistry data set includes measurements of nitrate, phosphate, and other solute concentrations at the mouths of the main stream and 10 tributaries over a 14-month period. These data were modeled using non-linear regressions that separate the dependence of concentrations on flow and season from their dependence on spatial variables. Models were tested that use either the rating curve approach or a semi-mechanistic equation for in-stream losses combined with separation of interflow and runoff. Both models showed a statistically-significant dependence of nitrate concentrations on farm extent, extent of near-stream saturated sediments, and tributary length. The results also suggest that the width of riparian vegetated

buffer alone was not a good proxy for the nitrate attenuation potential of a subcatchment, due to the varying presence or absence of near-stream saturated sediments in subcatchments.

B12A MC: Hall D Monday 1330h

The Science of Carbon Sequestration II Posters (joint with A, OS, V)

Presiding: G K Jacobs, Oak Ridge National Laboratory; **G H Rau**, Lawrence Livermore National Laboratory

B12A-01 1330h POSTER

The DOE Center for Research on Ocean Carbon Sequestration

Kenneth G. Caldeira (925 423-4191; kenc@llnl.gov)

Lawrence Livermore National Laboratory, 7000 East Ave. L-103, Livermore, CA 94550, United States

The US Department of Energy has created the DOE Center for Research on Ocean Carbon Sequestration (DOCS). DOCS is intended to be a center of expertise that can help conduct, focus, and advance the research necessary to evaluate and improve the feasibility, effectiveness and environmental acceptability of purposeful ocean carbon sequestration. The Center addresses fertilization and direct injection, and other ocean carbon sequestration strategies. It helps to advance our understanding of the biological, chemical, and physical processes that are critical to the ocean carbon cycle, and help us understand the effects of proposed sequestration strategies on this system.

The Center is operated jointly by Lawrence Berkeley and Lawrence Livermore National Laboratories (LBNL and LLNL), with the participation of researchers with relevant expertise from outside DOE.

We will present information on our instrument development efforts and results from ocean carbon sequestration simulations.

B12A-02 1330h INVITED POSTER

The Other Face of Soil Erosion and Deposition: A Surprising Carbon Sequestration Story From Cropland

Shuguang Liu (605-594-6168; sliu@edcmail.cr.usgs.gov)

Raythoen, EROS Data Center, Sioux Falls, SD 57198, United States

Soil erosion and deposition may play important roles in balancing global carbon (C) budget through their impacts on the net exchange of C between terrestrial ecosystems and the atmosphere. It is believed that reducing soil erosion leads to carbon sequestration in soils because soil carbon content on site increases following the application of conservation tillage that reduces soil erosion. In this study, a general ecosystem model EDCM (Erosion-Deposition-Carbon-Model), capable of dynamically simulating the influences of soil erosion and deposition on soil profile characteristics including soil depth and soil organic carbon, is developed based on the well-established CENTURY model and used to simulate the impact of rainfall-induced erosion and deposition on soil carbon dynamics. Model simulations were tested using field measurements collected from several landscape positions on the Nelson Farm site in the Mississippi River Basin, including ridge top, eroding hillslope, and depositional sites that had been converted from native forests to croplands since 1870. Results revealed several important findings. (1) Extrapolation based on soil organic carbon (SOC) content in surface soil rather than the whole profile could result in an overestimation of SOC loss from soil. SOC in the top 0.2 m layer reduced 31%, 47-60%, and 35-49% compared with the initial SOC under control (i.e., sites without erosion and deposition), erosional and depositional scenarios, respectively, after 127 years of cultivation. If the whole soil profile is examined, SOC loss was about 20% and 43-63% under the control and erosional scenarios. The SOC at the depositional sites increased 10-45%. (2) Soil-atmosphere C exchange experienced two distinct periods. Soil was a C source to the atmosphere at a mean rate ranging from 18 to 29 g C m⁻² y⁻¹ between 1870 and 1947. Soil became a C sink since 1948 with rates ranging from 26 to 29 g C m⁻² y⁻¹. (3) Although a total of 1457-2814 g C m⁻² was eroded from the eroding sites with the removal of 0.2-0.6 m top soil, erosion reduced C emissions by 11 to 37% during 1870-1947 and sequestered 12% more C since 1948 compared to the control. This result calls for reevaluation of the impact of soil erosion on carbon sequestration using a dynamic approach that accounts for the fate of the carbon that is eroded from the site. (4) Deposition