Nevada Water Resources Research Institute
Division of Hydrologic Sciences

Annual Technical Report
2018

General Information

Products

Project Title: Controls on Hydrologic Partitioning, Residence Time and Solute Export from a Snow-Dominated Watershed
Project ID: 2016NV217G

Peer Reviewed Publications
Carroll, R. H. H., Deems, J.S., Niswonger, R., Schumer, R., Williams, K.H. 2019. The importance of interflow for groundwater recharge in a snowmelt-dominated headwater basin. Geophysical Research Letters. 46. Doi: 10.1029/2019GL082447
Fang, Z., Carroll, R., Harman, C., Wilusz, D., Schumer, R., Williams, K. 2019. Streamflow partitioning and transit time distributions in snow-dominated basins as a function of climate. Journal of Hydrology. 570, 726-738. 10.1016/j.jhydrol.2019.01.029.

Conference Presentations
Carroll, R.W.H., Fang, Z., Bearup, L., Brown, W., Bill, M., Dong, W., Williams, K.H. (2018). Quantifying magnitude and age of groundwater flux from topographically complex watersheds and implications of a warming climate. MtnClim, Gothic, CO. Sept 17-12, 2018.
Carroll, R.W.H., Bearup, L., Fang, Z., Schumer, R., Deems, J., Brown, W., Bill, M., Dong, W., Williams, K.H. (2018). The Influences of snow accumulation on groundwater flux to streams in a Colorado River headwater basin. American Geophysical Meeting, Washington DC. December 10-14, Washington DC.
Carroll, R.W.H., Deems, J.S., Manning, A., Niswonger, R., Schumer, R., Williams, K.H. 2019. Snow and landscape controls on recharge and groundwater flux to streams. Environmental System Science (ESS) Principal Investigator Meeting. Bolger Center, Potomac, MD. April 29-May 1, 2019
Fang, Z., Carroll, R.W.H., Schumer, R., Harman, C.J., Wilusz, D.C., Williams, K.H. 2018. Hydrologic connectivity in snow-dominated basins as a function of climate. American Geophysical Meeting, Washington DC. December 10-14.

Invited Talks
Carroll, R.W.H., Snowmelt to streamflow: the importance of groundwater in mountain hydrology. Geosciences Colloquium, Boise State University, March 11, 2019
Carroll, R.W.H. (Keynote), Snowmelt to streamflow: the importance of groundwater in mountain hydrology. Hydrologic Sciences Research Symposium, University of Colorado, Boulder. April 11, 2019.
Carroll, R.W.H., Snowmelt to streamflow: controls on groundwater flow to a headwater stream. Lawrence Berkeley National Laboratory Science Focus Area Community Meeting, May 14, 2019.

Project Title: Degradation of Emerging Contaminants in treated wastewater using immobilized nano-zero valent iron
Project ID: 2018NV221B
None

Project Title: Evaluation of Antibiotic Resistance Genes (ARGs) in the Urban Wetland Ecosystem: Las Vegas Wash
Project ID: 2018NV222B
None

Project Title: Improving wastewater treatment using biofilms that degrade phenolic and aromatic contaminants
Project ID: 2018NV223B
None

Information Transfer Program

Project Title: Evaluation of Antibiotic Resistance Genes (ARGs) in the Urban Wetland Ecosystem: Las Vegas Wash
Project ID: 2018NV222B
The ongoing project to evaluate the prevalence of antibiotic resistance genes has been reported by NWRRI Newsletter on July 1, 2019, Volume 5, Issue 3. In addition, a video documentary on water and sediment sampling from the Las Vegas Wash to identify antibiotic resistance genes has been made and disseminated by DRI via

Facebook, Instagram and YouTube in August 2019 (https://www.youtube.com/watch?v=0PfRxzM6GDs).

Project Title: Info Transfer - Newsletter/Website
Project ID: 2018NV224B
This information transfer project serves to maintain the Nevada Water Resources Research Institute (NWRRI) website and disseminate a quarterly newsletter which spotlights specific research projects, PIs, and students. The website is available at: https://www.dri.edu/nwrri

Student Support

6 undergraduate students, 1 graduate student and 1 post-doc supported with annual base (104b) and required matching funds, National Competitive Grant Program awards.
0 students supported under the NIWR-USGS Student Internship Program and other Coordination Grant awards during the reporting period

Notable Achievements and Awards

Project Title: Controls on Hydrologic Partitioning, Residence Time and Solute Export from a Snow-Dominated Watershed
Project ID: 2016NV217G
Research funded through the base grant (104g) has been successfully leveraged with the Department of Energy (DOE) Watershed Function Science Focus Area (SFA). Stream concentration-discharge data and airborne snow observatory LiDAR mapping and snow chemistry have been used to support gas tracer collection across groundwater subcomponents and model development funded through the 104g base grant. Through this successful leveraging, Dr. Carroll has been promoted to the SFA executive committee, served on the SFA proposal renewal (May, 2019) and the DOE Early Career Panel (June, 2019).

In addition, USGS base grant outcomes (data and models) have been used to support additional grant activity to DOE, NSF, DRI as well as outreach to the USGS NGWOS proposal efforts for the Gunnison River. The DRI Maki grant was funded. The DOE and NSF grants were declined but will be resubmitted with modification in the next fiscal year.

Projects

Controls on Hydrologic Partitioning, Residence Time and Solute Export from a Snow-Dominated Watershed

Project Type: National Competitive Grant **Project ID:** 2016NV217G

Project Impact: We combined snow observations across scales with chemical and isotopic observations, groundwater dissolved-gas tracers, and numeric models of the East River, CO to explore first-order controls on groundwater flux to streams, age of hydrologically active groundwater, and baseflow age-distribution sensitivity across gradients in climate and watershed characteristics. Results indicate that groundwater is an important and stable source of water to this mountain stream with preferential recharge zones established in the upper sub-alpine that are partially decoupled from annual climate variability and resilient to historic drought. Baseflow ages estimated using dissolved concentrations of SF6, CFCs, N2, and Ar in stream water suggest a median age of approximately 10 years. This result aligns with groundwater age tracer data collected from springs and wells in the watershed. The tracer-derived median age is used to constrain alluvial and bedrock effective porosity in an integrated hydrologic model. The resulting particle-tracking age distribution produces a larger standard deviation than suggested by the tracer experiment. The spread of the distribution is dictated by geologic structure in which a significant component of younger water moves through the basin's alluvium underlain by igneous bedrock, while the bulk of older water occurs in the more permeable and steeply dipping sedimentary strata as well as along high mountain ridges. Using the tracer-informed numerical model, we are exploring baseflow age distributions as a function of aridity across a range of geologic and forest cover parameterization.

Degradation of Emerging Contaminants in treated wastewater using immobilized nano-zero valent iron

Project Type: Annual Base Grant **Project ID:** 2018NV221B

Project Impact: Current research results suggest the initial supporting material used to immobilize zero-valent iron nanoparticles (perlite) did not show enough surface area and porous for the nZVI particles to properly attach. We found the material allowed fast nZVI oxidation decreasing its efficiency significantly. Additional tests are currently on going to assess the capability of the oxidized iron nanoparticles attached to the surface of perlite as potential promoters of Fenton-like processes for the degradation of emerging contaminants in water. The lack of good results using perlite as the solid matrix for nZVI immobilization led us to test the efficiency of nZVI particles immobilized in the surface of synthetic Santa Barbara-15 (SBA-15). The novel synthesized material, SBA-15/nZVI, have promising results by the addition of potassium permonosulfate (PMS) as oxidant, a significant reduction in the antibiotic concentration (approximately 90%) has been achieved using 1g/L of SBA-15/nZVI for antibiotic concentration as high as 25 mg/L. Antibiotic concentration has been followed with HPLC analysis and the methodologies for running batch experiments and follow up the remaining biological activity in water after the degradation process have been established. The tests to assess the remaining biological activity after the degradation processes will be run once the best experimental conditions have been confirmed with Sulfamethoxazole and replicated with the other three proposed antibiotics. The characterizations and synthesis process for the immobilization of nZVI onto perlite and SBA-15 have been completed and SBA-15 has shown to be able to support higher loads of nZVI than perlite.

Evaluation of Antibiotic Resistance Genes (ARGs) in the Urban Wetland Ecosystem: Las Vegas Wash

Project Type: Annual Base Grant **Project ID:** 2018NV222B

Project Impact: Water and sediments were sampled for antibiotic resistance genes (ARGs) determination from five locations along the Las Vegas Wash in January 2019. Water was filtered through a 0.22 µm filter on site to capture bacteria. Sediments were collected using a core sampler, and the upper aerobic and lower anaerobic horizons were sampled separately. All samples went through DNA extraction in-house subsequently. qPCR was applied to identify and quantify 16S rRNA, ampC (gene resistant to penicillin), sul 1 (gene resistant to sulfamethoxazole), sul 2 (gene resistant to sulfamethoxazole), vanA (gene resistant to vancomycin), tetO (gene resistant to tetracycline), and tetW

(gene resistant to tetracycline). The total 16S rRNA ranged from 0.935 ×105 to 3.03 ×105 in water and 0.527 ×108 to 35.8 ×108 in sediments. All target ARGs were detected in both water and sediments. The most prevalent ARGs found were sul 1, sul 2 and vanA. For water samples, compared with the downstream site Las Vegas Bay, the upstream Las Vegas Wash wetlands had high levels of ampC, sul 1, and sul 2. In addition, tetO and tetW were not detected in the Las Vegas Bay site. For sediments, there is no clear trend between the upper and lower horizons, and the Las Vegas Wash sediments had more ARGs compared with the Las Vegas Bay. The results indicate that the Las Vegas Wash wetlands are an important reservoir of ARGs from receiving wastewater discharges, and ARG concentrations decrease before water flows into Lake Mead.

Improving wastewater treatment using biofilms that degrade phenolic and aromatic contaminants

Project Type: Annual Base Grant **Project ID:** 2018NV223B

Project Impact: The ability of soil bacteria to degrade phenolics has been tested under biofilm-forming conditions. Bacillus mojavensis and Bacillus cereus were grown in a synthetic medium with amino acids as sole carbon source. In this case, the bacteria grow by oxidizing amino acids with oxygen, a metabolism that generates hydrogen peroxide as a byproduct. In response to the resultant oxidative stress, the bacteria attached themselves to glass slides and form a thin biofilm. At this point, Congo Red was added and their concentration was monitored using a spectrophotometer. After two months, no appreciable decrease in Congo Red was detected, although the bacteria were still alive, suggesting that a thin biofilm does not provide sufficient oxidative power to degrade Congo Red. An improved bioreactor has now been devised to grow phenolics-degrading biofilms. Moving bed biofilm support was filled with glass wool, to increase the amount of surface area for bacterial attachment and to increase the volume for biofilms to grow thick. In addition, the bioreactor is actively aerated. Instead of pure cultures, a bacterial consortia from treated wastewater is used as inoculum. The bioreactor was periodically spiked with phenolics to train the biofilm to degrade. The efficiency of the improved reactor to phenols is being tested.