Earth Week

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Soil, Water & Environmental Science

Poster and Oral Presentation Guide

Index

Poster Presentations

Oral Presentations

Poster Presentations

Basil Alshebe, Graduate
Use of Biochar to Enhance Sorption of PFAS for in-situ Remediation of Soil and Groundwater
Advisor: Dr. M.L. Brusseau

Poly- and perfluoroalkyl substances (PFAS) are chemicals that are highly resistant to heat, oil, and water. They are used as protective coatings in many products such as in stain-resistant fabrics and non-stick cookware. They are also used in aqueous film-forming foam used for fire-fighting. Research has indicated possible toxicological effects of PFAS for humans such as cancer, fertility problems, and developmental effects for young children. PFAS are highly resistant to many soil and groundwater remediation methods. Sorption of PFAS to the soil can prevent long-range migration. Biochar is produced by the combustion of biomass under limited supply of oxygen. Biochar characteristics can reduce PFAS mobility and decrease the possibility of groundwater contamination. Also, conversion of biomass to biochar can be used as a method for carbon sequestration which would help in moderating climate change. In this research, column studies and batch sorption studies will be conducted on PFAS contaminated soil amended with different types of biochar. The concentration of PFAS will be measured using LC-MS. Immobilization of PFAS will be evaluated by comparing PFAS concentrations in leachate before and after amendment with each type of biochar. The results of this study will assess in selecting appropriate sorbent amendment to help remediate PFAS contaminated soils.

Alma Anides-Morales, Graduate
Sanitary Sewer Overflows in Naco, Arizona. Quantitative Microbial Risk Assesment at Naco Elementary.
Monica Ramirez-Andreotta, PhD; Charles Gerba, PhD; Diego Huerta

Naco, Arizona is immediately adjacent to its sister border city Naco, Sonora, Mexico. Transboundary untreated wastewater flows have recurrently affected the area for many years. Wastewater pollution is a major issue of concern worldwide because of the presence of pathogens and infectious microorganisms in polluted waters. Wastewater pollution often contains fecal matter which has high concentrations of pathogens. The proximity of the sewage overflows to Naco Elementary School, has raised questions as to the potential health risks to the students who attend this school. Through a collaboration between Cochise Health and Social Services (CHSS), Naco Elementary School, and the University of Arizona Soil, Water, and Environmental Science (SWES) department, a quantitative microbial health risk assessment will be conducted for the students of Naco Elementary. Surveys and informal interviews will be utilized to inform sampling locations and the risk assessment. Surface soil sample will be collected and analyzed for fecal indicator bacteria and reference enteric virus to quantify the presence of pathogenic organisms. Results from the risk assessment will be used to inform decisions regarding the future construction of a school garden, nature pathways, and help inform residents and assist CHSS in their preparedness and response to sanitary sewer overflows.

Yvonne Arias, Graduate
MS2 Bacteriophage Inactivation Rate on Mica and Stainless-Steel Carriers and Dessication Patterns on Inoculating Droplets
Luisa A. Ikner, Charles P. Gerba, Joan E. Curry

Norovirus (NoV) is a pathogenic enteric virus known to be the worldwide leading foodborne illness responsible for acute gastroenteritis. Institutions, healthcare facilities, restaurants, grocery stores, resorts, and cruise ships, all experience significant risk through person to person interactions and hand-oral route after contact with fomites, environmental surfaces and other materials previously exposed to vomit or feces containing the virus. No medical treatment has been developed for NoV as it is highly difficult to cultivate for research using traditional cell culture techniques. MS2 bacteriophage is a viral surrogate used as an alternative by researchers for the purpose of studying the behavior of norovirus. Recent efforts have concentrated on testing chemicals and other aerosol products to determine their potential for inactivating the MS2 virus on hands, fomites, and surfaces. Surfaces include glass, plastics, stainless-steel and wood, but there is no known testing done on mica surfaces. This study concentrates in the inactivation rate of MS2 bacteriophage on Mica carriers. The efficacy of the virus reduction is measured by comparing its inactivation rate on Mica to Stainless-steel carriers. Further testing will determine the impact created by relative humidity, salt concentrations, hydrophobicity and interactions with the air-water-solid interface. Enough virus reduction on mica can serve as an alternative to preventing the spread of illnesses such as Norovirus through the development in antimicrobial materials.

Matthew Bigler, Graduate
Manufacturing roughness into micromodels to visualize the effect of micro heterogeneity on interfacial area.
Advisor: Dr. M.L. Brusseau

The transport and fate of contaminants in subsurface systems containing multiple fluids is influenced by retention at fluid-fluid interfaces. The magnitude of this interfacial area is dictated by the surface properties of the solids and the pore–scale distribution of the fluids. Previous studies using various types of tracer tests to measure interfacial area as a function of water saturation have shown that total fluid-fluid interfacial area increases greatly at lower water saturations. In addition, the maximum fluid-fluid interfacial area is observed to equate to specific surface areas of the solids as measured by N2/BET analysis. These results reflect the fact that the surfaces of natural geological media are rough, and that water is present primarily as thin films at very low saturations such that the magnitude of the fluid-fluid interface mirrors the magnitude of surface roughness. Efforts in resolving these thin films have been largely unsuccessful due to resolution limits of X-ray micro tomography and other imaging methods. The objective of this research is to examine the influence of surface roughness and thin films on fluid-fluid interfacial area. Three-dimensional microfluidic models of varying micro-heterogeneity will be constructed to directly measure fluid-fluid interfacial area under different conditions in an effort to visualize and better understand this phenomenon.

Kyle Brown, Graduate

Microbial Contributions to Soil Health: Optimizing Guayule (Parthenium argentatum) Production in an Arid Environment

The Sustainable Bioeconomy for Arid Regions (SBAR) has proposed a coordinated plan to establish a sustainable regional bioeconomy in the Southwest U.S. through the cultivation of drought-resistant crops. Specifically, their approach is to optimize guayule (Parthenium argentatum) production to increase the value of the bioeconomy for rural, arid regions. Guayule produces latex which is very similar to Hevea brasiliensis and has long been recognized as an alternative source of rubber. Other guayule products of commercial value include organic resins and bagasse, the latter which can be used as a source of biofuel. Guayule is a drought-resistant crop which makes it suitable for sustainable production in the Southwest U.S. Optimizing guayule production requires an understanding of the desert soil microbial communities that are essential for soil health. Microbial contributions to soil health include: enhanced nutrient availability, pathogen protection, phytohormone production, and plant stress protection. The objective of the soil microbiome research is to develop soil health knowledge relevant to guayule feedstock production. Specifically, we hypothesize that irrigation type and rate will significantly impact the microbial composition of the guayule rhizosphere microbiome, and that significant differences in the soil microbiome status will correlate with guayule biomass production, plant height, rubber concentration, and resin content. It is critical to understand the effect of irrigation levels on guayule production for the establishment of an arid-land crop.

Nicholas Buchanan

Geochemical Impacts of Phytostabilization on Iron King Mine Tailings

Rob Root, Jon Chorover

The Iron King Legacy mine poses serious human health hazards to local Dewey-Humboldt residents and the nearby Agua Fria River. A national Priorities List Superfund Site since 2008, the legacy mine has initiated significant professional and academic remedial action. Phytostabilization of the onsite mine tailings is an emerging mitigation strategy to reduce the bioaccessibility of arsenic, zinc, and lead in the pyrite derived mine tailings. Facilitated plant growth on the surface of Iron King Tailings has successfully reduced the wind dispersion and ultimately the bioaccessability of the toxic tailings. Yet questions remin on subsurface geochemical impact of phytostabilization on mine tailing mineralogy. A phytostabilization on the Iron King Mine tailings. Tailings from different depths in the site were homogenized, composted, treated with one of two different seeds, and added to a 314 L mesocosm. Buffalo grass (Bouteloua dactyloide) and quail bush (Atriplex lentiformas) were grown in mine tailings amended with 15 wt % compost. Core samples were collected throughout the plant life spans (0, 3, 6, 9, 12, 24 months). A specific sequential extraction (SSE) followed by mass spectrometry and X-ray absorption spectroscopy is being conducted on Iron King Mine tailings treated through greenhouse phytostabilization to characterize its effects on mine tailing geochemistry. The SSE consists of lab pure water (1), which is operationally defined as being able to dissolved soluble salts in the tailings. This is followed by ammonium acetate (2), targeting non-specifically sorbed ions. Then sodium phosphate (3), which was included to specifically target adsorbed arsenate ions (PO43- for AsO 43-). Following this is ammonium oxalate followed by an acid wash(4), which can targets dissolving iron oxide minerals in the tailings to release coprecipitated As. After this two-step extraction is a citrate-bicarbonate-dithionite (CBD) extraction (5), which will oxidize crystalline iron oxides in the tailings releasing any incorporated or stoichiometric As ions. Finally a hydrogen peroxide and nitric acid step (6) is included to dissolve any residual contaminants within parent tailing sulfidic species. Phytostabilization has shown promise as a health risk mitigation technique in semi-arid mine tailing sites like Iron King. Yet significant questions on the impact of the technique on mine tailing geochemistry must be answered before widespread adoption and implementation.

Joy Custer, Undergraduate

Optimizing Nycodenz density gradient centrifugation methods for soils

The majority of soil biodiversity is uncultured, primarily because many uncultivated lineages are oligotrophic and do not grow on typical growth media. While there are several oligotrophic cultivation methods for marine environments, these methods are challenging to use in soil. This paper discusses the process of optimizing a Nycodenz density gradient centrifugation method to separate viable cells from soil and culture them. Although most methods claim that all cells are in the milliliter immediately above the Nycodenz after centrifugation, the flow cytometry results of this experiment show that there are cells throughout the gradient. DNA extraction needs to be performed on the cells from this modified protocol to conduct a community analysis and determine if different bacterial taxa are at different fractions on the Nycodenz gradient after centrifugation.

Sean Day, Graduate

Marketable Yield and Quality of Yukon Gold Potatoes in Response to Organic Seed Treatments and Varied Interval Irrigation Schedules

Under ideal conditions, organic potato growers have thin margins for profits, so preventing disease is of utmost importance to this billion-dollar industry. Significant economic losses are caused by a soil-borne disease called common scab that creates superficial pitted-lesions on the skin of potatoes. Although yields are not typically reduced by scab, marketability is significantly diminished in tuber cultivars not being used for processing. Yukon Golds are sold as table stock so esthetics is vital for consumer confidence (II). This variety is particularly susceptible to several strains of Streptomyces that cause scab because of their delicate flesh. Since, potatoes can tolerate acidic soils and scab cannot, organic farmers will exploit these characteristics by maintaining the soil pH in the (4.5 to 6.0) range. However, lowering the soil pH is expensive, reduces yields, may not be effective, and is detrimental to the health of the soil which can lead to dustbowl conditions (V). While several tools can be used to impede scab in conventional potato production, few tools exist in organic tuber cultivation due to stringent guidelines for certified USDA Organic production (II). It is critical growers be given alternate methods that allow them to have timely crop rotations while preventing lesions from decimating their profits. Focusing on marketable yield and quality of Yukon Gold production, the aim of this Randomized Complete Block Design (RCBD) experiment under field conditions is threefold: (1) to evaluate the effectiveness of elemental Sulphur (ES) seed treatments and (2) diatomaceous earth (DE) seed treatments when exposed to the same volume of water but delivered in increased interval micro-volumes (I1) or decreased interval macro-volumes (I2), and (3) compare the effectiveness of the two seed treatments when exposed to the two different irrigation schedules.

Preliminary data suggests that DE and S treatments negatively impact marketable yields but more research is needed. The data also suggests that untreated tuber seeds when exposed to I1 treatments, showed significantly higher yields than all six treatments. However, I1 treatments did indicate a slight increase in salinity. I2 treatments all leached more nitrates outside the root-zone but did have lower salinity regardless of seed treatment.

Kristin Dietzel, Undergraduate

Understanding the geographical distribution of fungal plant pathogens

Albert Barberan, Denis Valle, Jana U'ren

The prevalence and severity of outbreaks caused by virulent fungal plant pathogens have increased during the past two decades and are recognized as emergent threats to worldwide food security. The geographical distributions of plant pathogens are impacted by their host distribution and susceptibility levels, as well as crop management and climatic factors. Hower, pathogens also may cause disease under suitable conditioned. Thus, the ability to track the long-distance dispersal and the geographical distribution of fungal pathogens is essential for forecasting plant disease spread and for establishing effective quarantine measures. Using near-surface dust samples collected across the United States, we explored the geographical distribution of fungal plant pathogens by using a combination of machine learning tools (i.e. gradient forests and Latent Dirichlet Allocation models) to understand: 1) the impact of environmental and agricultural factors on the composition of fungal plant pathogen communities, and 2) the potential of delimiting geographical regions based on the prevalence of fungal plant pathogens in dust as compared to distributions based solely on disease occurrence. This information can be used to inform landscape epidemiology and to predict the future effects of climate change on plant diseases.

Ahmet Emin, Graduate

Hydrogeochemical Modeling of Uranium

Transition metal and actinide elements are generally found in their ionic forms in water. Their transport in porous media is significantly affected by physical and chemical conditions of the groundwater and surrounding environment. A primary process affecting transport is adsorption onto the surfaces of soil grains. Sorption is generally nonlinear and/or rate limited in many systems. Transport is also affected by physical and geochemical heterogeneity of the porous media, which exists at multiple scale ranging from pore to field scale. In addition, transport is affected by contaminant form (e.g., speciation), which is highly influenced by environmental conditions, microbial activity, and groundwater chemistry. Hence, the transport of uranium in the subsurface environment is very complex. Simulating transport in such complex systems requires the use of multi-component reactive transport models. The objective of my planned research is to investigate the mechanisms influencing the sequestration and transport of U at a field site at which in-situ biosequestration pilot studies have been conducted to remediate groundwater contaminated by U, nitrate, and sulfate.

Dawson Fairbanks, Graduate

Investigating seasonal responses of soil microbial nutrient cycling in high elevation forests in northern New Mexico

Chance Muscarella, Virginia Rich, Rachel Gallery

Precipitation driven fluctuating redox transformations structure microbial communities, influencing rates of microbial nutrient cycling and fluctuations of greenhouse gas fluxes in forest soils. The goal of this study was to understand the relative contributions of precipitation, substrate quality, and temperature on microbial nutrient cycling in a high elevation forest. These forests are important carbon sinks in the western United States and the productivity and disturbance regimes of these seasonal and highly dynamic ecosystem is largely driven by bimodal precipitation regimes that result in increased soil respiration during peak moisture events around spring snowmelt and summer monsoon seasons. We investigated the seasonal controls over soil microbial carbon and nutrient cycling in a sub-alpine ecosystem in northern New Mexico in the Jemez River Basin, CZO field site sampling during snowmelt, before-, during- and after the monsoon season across an instrumented watershed. We measured the dissolved organic C and N pools, microbial biomass, microbial exoenzyme activities involved in C, N, and P cycling and to understand microbial contribution to water-driven pulses of soil CO2. In addition, we determined the role of temperature sensitivities of the microbial communities in decomposition as they vary throughout the growing season to understand variations in temperature response over time, and its drivers. Temperature sensitivity of soil enzymes can be important to evaluate when considering the responses of soil nutrient cycling to climate warming scenarios. We found variations in the above measured variables during the growing season where concentrations of dissolved nitrogen peaked during the spring snowmelt event. Microbial biomass C and dissolved organic carbon peaked during the monsoon event but did not result in elevated carbon and nitrogen exoenzyme activities which peaked in the fall. We also found variations in temperature sensitivity response during the growing season for select C and N degrading enzymes that peaked during the summer monsoon event. We hypothesize that these shifts in Q10 response may be due to either a) change in substrate affinity (Km) which may reflect shifts in microbial community structure, b) change in quantity and quality of substrate, affecting the reaction rates of enzyme-catalyzed processes, or c) increased diurnal temperature fluctuations which may result in increased selective pressure on microbial communities during the spring and fall. Future work will look at how observed changes in functional potential may reflect shifts in community composition and seek to identify the organisms carrying out these key decomposition pathways via metagenomic analysis.

Lijun Fan, Graduate

The Arsenic behavior of Natural Tailing Sediments in Microcosms with sulfate reducing bacteria

Fenghua Zhao, Jing Liu, Ray L. Frost

Arsenic (As) pollution is an increasing worldwide concern because of its adverse impact of toxic, carcinogenic and teratogenic properties on human health. Extensive mining exploitation of arsenic sulfides have generated large amounts of high arsenic tailings. The reductive dissolution of these tailing sediments at the soil/water interface influences the behavior of arsenic (As). Here, the dynamics of As in the flooded high arsenic tailing sediments from Shimen abandoned realgar mine (Hunan, China) at circumneutral pH conditions were investigated by employing a pure culture of a sulfate reducing bacteria (SRB) and amended with a combination of lactate, sulfate and calcium. Changes in Eh, pH, aqueous Fe(II) and As speciation were monitored during the 7 days incubation. Our results demonstrated that SRB was able to reductive dissolve high levels of arsenical ferric oxyhydroxide tailings. The results showed that reactions with aqueous As(III) and As(V) presented different trends, with As(III) being the dominant arsenic species. Aqueous As behavior showed two distinct stages, firstly, the As(V) was released and immediately reduced to As(III) by biogenic sulfide. Next, the released As was removed from the solution by adsorption onto newly formed iron sulfides or co-precipitation with S(-II) to produce arsenic sulfide. In addition, the addition of sulfate, calcium and sodium lactate played different roles in the release of As. Addition of sulfate and sodium lactate can trigger the release of arsenic, while calcium caused the opposite effect. This knowledge will be be beneficial for developing subsequent remediation techniques for arsenic-impacted mine tailings site worldwide, including the Iron King Dewey-Humboldt Superfund site in central Arizona, USA. This Superfund site has similar geologic and anthropogenic mining history with high levels of arsenic contamination (up to 3000 ppm)

Cody Folk, Graduate

Influence of Eolian Inputs on Pedogenic Processes across a Semi-Arid Basalt Chronosequence on the Colorado Plateau.

Craig Rasmussen, Andrew Kowler, Stephen Hart

The Colorado Plateau offers a unique window to document pedogenic processes in a semiarid environment. We analyzed soil samples collected from a three million-year chronosequence of basalt flows in the San Francisco Volcanic Field near Flagstaff, Arizona. We hypothesized that eolian inputs provide a significant amount of material to the soil and drive chemical weathering and soil formation processes. We quantified soil mineralogical and physicochemical properties and found distinct time trends in soil pH, particle size distribution, geochemistry, and mineral phases. Data indicated significant decreases in pH and Ti:Zr ratios with pH decreasing from 8.3 to 7.7 and Ti:Zr decreasing from 70:1 to 17:1. This is accompanied with primary mineral abundance that corresponded with an increase in reddening and clay from an average of 6.8 to 56.4 percent clay as soil age increases. The mineral assemblage and geochemical signature of soils indicated increasing contribution of dust to the mineral fraction with increasing age, with the oldest site estimated to be nearly 100% eolian derived in the upper 50 cm. The combined data document a clear role for dust and primary mineral weathering across this semiarid chronosequence.

David Hans Gieschen, Undergraduate

The Role of Abiotic and Biotic Factors in Controlling the Dynamics of Dissolved Organic Matter in a Peatland Ecosystem

Malak Tfaily

Dissolved organic matter (DOM) is an important component of peatland ecosystems. It acts as an energy source for microbial life and can have widespread effects on chemical and biological properties, as well as on the systems CO2 production rates. Quantifying biotic and abiotic controls on sphagnum leachate DOM dynamics (a key component of permafrost peatland ecosystems) using high resolution mass spectrometry is critical to mapping the global C budget and a key to understanding peatland ecosystem functions. As the climate warms, permafrost peatlands are expected to melt down, leading to the release of tens of billions of tons of carbon into the atmosphere. Understanding DOM transformation and degradation can provide important information about peatland chemistry, and can help improve C-cycling models, and climate change models. In this experiment, sphagnum moss was leached into aqueous solution. The resulting DOM was then filtered and sterilized. Samples were then incubated at in situ conditions in the lab with and without microbial communities (microbial inoculum will be prepared from the soil below the surface vegetation), and with and without beta-glucosidase, while monitoring CO2 production. Eight replicates were produced for each treatment. One replicate was sacrificed for analysis each week for analysis by high resolution mass spectrometry. Our preliminary experiments highlight the importance of considering abiotic mineralization and indicate the potential to identify chemical markers indicative of biotic vs. abiotic mineralization. This suggests that abiotic reactions result in complete mineralization of DOM into CO2 whereas biotic reactions appeared to degrade and produce DOM. These differences suggest that abiotic and biotic mineralization will leave distinct signatures in high resolution DOM profiles. This research is an attempt to influence scientific experiments pertaining to peatland carbon cycling processes by analyzing C decomposition in order to improve large scale system modeling. This work aims to advance peatland understanding as a hydro-biogeochemical system and how these systems respond to changes in water quality, land use, vegetative cover, and snowmelt timing. Our future goals include quantifying how biological behavior, abiotic-biotic interactions, and DOC transformation mediate bioavailability of nutrients.

Sarah Van Glubt, Graduate

The Influence of multi-process retention on the transport of perfluorooctanesulfonic acid (PFOS) in the presence of non-aqueous phase liquids (NAPLs)

Ni Yan, Yake Wang, Mark L Brusseau

Per- and poly- fluorinated alkyl substances (PFAS) are of concern because of their persistent nature, widespread occurrence, and potential risks to human health. Immiscible organic liquids often co-occur at certain PFAS-contaminated sites. The impact of NAPL on the transport of PFAS has not been fully examined. The objective of this research is to characterize and quantify the contributions of solid-phase adsorption, NAPL-water interfacial adsorption, and partitioning to bulk NAPL to PFAS retention during transport in porous media. Perfluorooctanesulfonic acid (PFOS) is used as the model PFAS as it is a primary PFAS of concern due to its long history of use and observed presence at many sites. Interfacial tensions are measured to quantify the contribution of NAPL-water interfacial adsorption to retention, while NAPL-water partitioning experiments are used to quantify the contribution of NAPL partitioning. Column experiments are conducted with several porous media comprising different physicochemical properties to examine their influence on PFOS retention.

Mohammad Gohardoust, Graduate

Hydraulic and Aeration Properties of Soilless Greenhouse Substrate Mixtures

Dr. Markus Tuller

With the global population projected to grow to more than 8 billion by 2024, irrigated agriculture faces momentous challenges to keep up with the increasing demand for adequate food supplies, especially in the arid regions of the world. As a result, soilless culture is regaining increased attention as it allows a more sustainable management of production resources along with higher achievable crop yields. Individual soilless substrates with desirable and complementing properties for plant development and production are commonly mixed at varying ratios. Organic components, such as coconut coir, often lack coarse particles necessary for adequate aeration and they hold moisture relatively tight in small pores. To optimize aeration and water holding properties they are commonly mixed with coarser materials such as volcanic tuff to create larger pores that rapidly drain after irrigation, thereby creating optimal rhizosphere conditions that can be tailored for a specific crop. Such mixtures often exhibit bimodal pore size distributions and water retention characteristics, where the fraction of smaller pores mainly retains water and the larger pore fraction allows for optimal aeration. The optimum mixing ratios are commonly selected through trial and error by growing plants in a series of mixtures. Replacing this trial and error approach with physical relationships for prediction of mixture behavior from well characterized constituent properties will significantly advance soilless culture production and eliminate costly mistrials. Based on this premise, the hydraulic properties of three mixing ratios of dual component substrates made up of perlite, tuff, and coconut coir have been studied. Constitutive relationships parameterized with hydraulic properties of individual components will be presented.

Anna Gresham, Justin Clark, Undergraduate

Identification of sources of fecal contamination in irrigation waters for production of leafy green crops in Arizona

Christina Morrison, Patricia Gundy, Kelly Bright, Charles Gerba, Walter Betancourt

Identification of the source of fecal pollution (human vs. animal) is critical in the assessment and mitigation of fecal pollution in water. Irrigation water has been implicated as a major source of pathogen contamination in leafy greens. The risk of disease transmission from foodborne pathogens present in irrigation water is influenced by the level of contamination and the route of exposure, as well as the persistence of pathogens in water, in soil, and on crops. Arizona and California produce 90 percent of the leafy greens consumed in the United States and both States rely on irrigation canal systems to water crops. This study investigates potential sources of contamination with foodborne pathogens in irrigation waters using genetic markers associated with fecal bacteria unique to cattle, swine, birds, and humans. The presence of Salmonella is also investigated as a major foodborne pathogen along with generic E. coli, the microbial standard established on the Food and Drug Administration (FDA) Food Safety Modernization Act (FSMA) for irrigation waters. Currently, eighteen water samples for irrigation canals have been collected from two major water irrigation districts in Arizona. Membrane filtration is used for concentration of fecal bacteria and Salmonella while generic E. coli is evaluated with Colilert® defined substrate technology. Out the 18 samples collected, none of them has exceeded 126 colony forming units (CFU)/100 mL (FSMA microbial standard).However, four presumptive Salmonella species have been isolated from four sampling sites in two counties using selective media and are pending further confirmatory tests. Quantitative real time polymerase chain reaction assays will be used for detection and quantification of host-specific bacterial genomes, which will help us to estimate levels and sources of fecal contamination. The assessment of fecal genetic markers will aid in the accurate identification of the type of host inputs (e.g., sewage, wildlife, agricultural) and consequently the reservoirs or sources of foodborne pathogens like Salmonella that will result in a more accurate assessment of the risks to human health.

Dominika Heusinkveld, Graduate

Lead exposure in children living near a legacy mine and copper smelter in Hayden-Winkelman, Arizona

MPH; Tania Rodriguez; Eduardo Saez, PhD; Eric Betterton, PhD; Monica Ramirez-Andreotta, PhD

Lead exposure has been shown to be harmful to humans in various settings. Lead is particularly harmful to children, in whom it can cause neurological problems, low IQ, developmental delay, and other health issues. There are no safe levels of blood lead in children. Hayden-Winkelman neighbors the ASARCO Alternative Superfund site where lead exceedances in air and soil have been measured in the past 20 years. An important question is whether these lead levels can be expected to impact the health of children in the community, since those of age 7 and under are particularly vulnerable to the effects of lead. Over 140 children under age 11 live in Hayden and Winkelman. The majority of these children live within a quarter-mile of the smelter. This project focuses on assessing their risks.

We use the Environmental Protection Agency's Integrated Exposure Uptake Biokinetic (IEUBK) model to estimate blood lead levels in a hypothetical child population with site-specific lead exposure parameters measured at Hayden-Winkelman: indoor air, outdoor air, soil, indoor dust, and water. Lastly, values used by the Arizona Department of Environmental Quality's airborne lead risk forecast are also evaluated to determine whether the forecast provides an accurate representation of risk for children in the community when coupled with other measured lead exposures on the site.

Shelby Hoglund, Graduate

Increasing soil carbon for future water solutions and desert agricultural sustainability

Shelby Hoglund, Joseph Blankinship

The future of Arizona's agriculture is unknown as the uncertainty in water availability and soil health lingers. Desert soils are known to contain little organic matter which limits their ability to retain water. Biochar is a product made from recycled organic waste that can provide soil with much needed organic carbon. The porous structure of biochar may allow water, nutrients, and microorganisms to enter and remain in micro-pores until plant roots reach them. Previous studies suggest that biochar increases the water-holding capacity of soils while also increasing the microbial activity and nutrient retention, all of which could improve crop productivity. Does applying biochar in arid agricultural soils have real-world benefits to soil health improvements? Our main goal is to quantify the effects of adding biochar on soil nutrient dynamics, water use, and crop yields in Arizona croplands. Our first objective was to determine which biochar feedstock is most effective at increasing the water-holding capacity of a Sonoran Desert soil. Our second objective was to optimize the amount of biochar added to increase the soil water retention by 25,000 gallons per acre. The field-scale effects of restricting irrigation water by up to 50% after the application of biochar will be tested with White Sonora wheat at the University of Arizona Campus Agricultural Center. Our third objective was to quantify soil nitrogen and phosphorus retention by quantifying their losses through leaching and gas emissions. These objectives can provide implications for future studies involving carbon inputs to soils, water conservation, and sustainable agriculture in the Desert Southwest.

Jenna Honan, Graduate

An Ecological and Health Risk Assessment of the Upper Santa Cruz River Using Environmental Management Tools

Many cities are bolstering their local water recharge by directly discharging treated wastewater effluent into the environment. The treated water then permeates through the vadose zone and into the aquifer, thereby recharging groundwater. The Nogales International Wastewater Treatment Plant (NIWTP) releases effluent wastewater directly into the Santa Cruz River. The Santa Cruz River flows between the United States and Mexico through several metropolitan areas. An issue of critical concern is the long-term impact of the discharge of treated effluent from the NIWTP to surface water and groundwater quality in the region. Several factors including failing infrastructure, operational limitations, and continued rapid population growth impart complexity to this issue. The affected community is generally low- to middle-income, so the costs for obtaining and maintaining new and advanced treatment options necessary for the removal of contaminants of emerging concern is economically burdensome. A recent study has shown that the discharge point of the NIWTP is in an area of high aquifer vulnerability and that there is evidence of environmental contamination from the presence of cadmium, chromium, copper, nickel, nitrates, and zinc, among other compounds. The objective of this study is to identify and assess areas of potential soil and groundwater pollution and associated risk to environmental and human health using modeling and environmental management tool analyses.

Xiaobo Hou, Graduate

Vegetation Change On Navajo Farmlands Along The San Juan River After The Gold King Mine Spill Using Remote Sensing

Xiaobo Hou, Karletta Chief

After the Gold King Mine Spill (GKMS) in August 2015, Navajo communities were concerned about using the San Juan River for farming, ranching, recreation and cultural practices. Although, the river was deemed to meet agricultural standards several weeks after the spill, many Navajo farmers did not resume farming activities or use of irrigation water. However, the decrease in farming activities on the Navajo Nation due to the Spill is not quantified as a whole due to lack of records for farming before and after the Spill. The objective of this study is to determine change in vegetation greenness and water stress level to examine change in farming practices and evaluate its impact on farmland productivity using different vegetation indices (VIs). Preliminary results showed that one year after the GKMS, there was a 20% decrease in croplands and a relative 20% increase in fallow land along the San Juan River on the Navajo Nation between Upper Fruitland and Shiprock chapters. The result of this study will help researchers and policy makers understand the risk perception of the Navajo farming communities along the San Juan River.

Amanda Howe, Graduate

Bradyrhizobium in Soil: Not Just for N-Fixation Anymore

Taxa within the Bradyrhizobium genus have been economically valued, and well characterized, for their ability to form symbiotic relationships with legume plant roots within the plant's rhizosphere. Symbiotic Bradyrhizobium form and live within legume root nodules, where they chemically alter atmospheric nitrogen, through a process called 'Nitrogen-fixing', into molecular forms that the legume can utilize for nutrition. It's been thought that N-fixation were Bradyrhizobium's only function, as this symbiosis results in Bradyrhizobium receiving carbon sources from legume roots. Yet in recent studies, Bradyrhizobium has also been found at high abundances at various depths in bulk soil, outside of the influence of legume rhizospheres. More interest is being put into studies that quantify the relative amount of non-N-fixing, non-symbiotic Bradyrhizobium living both within legume and non-legume rhizospheres and within bulk soil. By studying non-symbiotic Bradyrhizobium in bulk soil, we can begin to hypothesize where these taxa are receiving their growth and energy sources. Due to their high abundances in bulk soil, these studies could also uncover important implications in Bradyrhizoibum's role in soil carbon and nitrogen cycling, and in our understanding of climate change on a global scale, as soil is becoming more appreciated for its ability to act as a carbon sink. My proposed project will use a mix of culturing, transcriptomic, and exometabolomic methods under different growing conditions in order to can gain a better understanding of the influence of non-symbiotic Bradyrhizobium on biogeochemical cycling in soil.

David Huskey, Graduate

Just the tip: detection of lead (Pb) on corn root tips using rhodizonic acid

Gilberto Curlango-Rivera, Martha Hawes

Lead (Pb) is a contaminant whose removal from soil remains a challenge. In a previous study, border cells released from root tips were found to trap Pb, alter its chemistry and prevent root uptake. Rhodizonic acid (RA) is a forensic tool used to reveal gunshot residue, and also to detect Pb within plant tissues. Here we report its application to visualize dynamics of Pb accumulation at the root surface. Corn root tips were immersed in Pb solution, stained with RA, and observed microscopically. Pb trapping by border cells was evident within minutes. The role of extracellular DNA was revealed when addition of nucleases resulted in dispersal of RA-stained Pb particles. RA is an efficient tool to monitor Pb-root interactions. Trapping by border cells may control Pb levels and chemistry at the root tip surface. Understanding how plants influence Pb distribution in soil may facilitate its remediation.

Brenda N Ibarra-Castillo, Graduate

A Novel Approach for Estimation of Farm Scale Actual Crop Water Consumption from Remotely-Sensed Surfaces Soil Moisture

Ebrahim Babaeian and Markus Tuller

The Southwestern U.S. and many other arid and semiarid regions around the world face serious water shortages that are projected to have significant adverse impacts on irrigated agriculture. Agriculture is not only one of the major consumers contributing to water scarcity, but also has the largest potential for conservation. Hence, accurate knowledge of the soil moisture status and plant available water is crucial for precise irrigation management aimed at improving crop water productivity and thereby contributing to water conservation. For my thesis research I will combine the recently developed OPtical TRapezoid Model (OPTRAM) for estimation of surface soil moisture from remotely-sensed shortwave infrared (SWIR) land surface reflectance with a novel analytical net water flux model to determine actual crop water consumption (i.e., evapotranspiration). Ultrahigh resolution SWIR observations obtained with the TERRA REF phenotyping scanner, one of the world's largest field robots located in Maricopa, Arizona, will be initially employed to develop the proposed approach. The accuracy of the soil moisture maps obtained with OPTRAM is evaluated based on a comparison with ground reference measurements obtained with a Time Domain Reflectometry (TDR) sensor soil moisture monitoring network. The resultant framework for estimation of crop water consumption can be applied in conjunction with Unmanned Aerial System (UAS) observations to assist with farm scale precision irrigation management for improving water use efficiency across cropping systems.

JoRee LaFrance, Graduate

Contaminant behavior in the Indige-FEWSS nexus: A case study of food-energy-water interactions in the Little Bighorn River watershed, Crow Reservation, Southeastern MT, USA

In addressing interrelated issues like soil and water contamination, food and water security, and environmental policy in Indigenous communities, it is important to consider all aspects of the Indigenous food, energy, and water security and sovereignty (Indige-FEWSS) nexus. The Crow Reservation located in southeastern Montana is home to the Little Bighorn River (LBHR). The LBHR acts as the main water source for agriculture development, municipal systems and irrigation canals on the eastern side of the reservation. Specifically, elevated levels of uranium have been detected in private home wells along the alluvial deposits in the LBHR watershed where 68% of the 97 wells had uranium present (>1 ug/L) and 6.3% exceeded the EPA maximum contaminant level (30 ug/L), posing health risks to community members (Eggers et al 2015). Metals may be deriving from mining activities associated with the energy industry, or from natural weathering processes in the shale bedrock underlying the watershed. Other contamination issues of concern involve bacteria, as the Crow Environmental Health Steering Committee (CEHSC) has performed studies finding that bacteria such as "Mycobacterium, Legionella and Helicobacter species are in both treated municipal water and untreated well water" (Eggers et al 2015). Within private home wells relying on the groundwater sources in this watershed, Eggers et al found that inorganic contaminants (U, Mn, NO3-, Zn and/or As) pose risks in 39% of the 164 home wells they tested. Although, most literature focuses on groundwater contaminants within this watershed, there has been minimal research done on the connection of these groundwater sources to surface water quality of the LBHR. Furthermore, LBHR surface water is transported to land application through the Crow Irrigation Project (CIP), a series of canals that serves as the foundation of the Indige-FEWSS nexus as it has provided water since 1904 to agriculturally-developed areas in the valley. Water percolating through agroecosystems is then returned to the river following vadose zone leaching and groundwater recharge. This could result in accumulation of river-derived metal(loid)s in agricultural products and transport to the river of pesticides as well as fertilizer constituents (e.g., N, P), which can promote eutrophication. Seven of the eleven irrigation units on the reservation are specifically located along the LBHR corridors raising concern on how agriculture may impact – and be impacted by – surface water quality. The aim of this study is to address the Indige-FEWSS nexus from a LBHR watershed perspective on the Crow reservation, recognizing how metal, potential pesticide and/or nutrient contamination affects this system and investigating possible solutions and recommendations. Research questions being considered include but are not limited to: What is the source of toxic metals in the LBHR? To what extent is the CIP serving as a source or a sink for contaminants? How is LBHR water quality altered by the CIP system? Is there contamination coming from specific agriculture fields or irrigation systems? What are the implications for agricultural standards and the ability to obtain Treatment as a State (TAS) status under the Clean Water Act?

Ariel Leger, Graduate
Jamee Lyon, Undergraduate

The antimicrobial molecular composition of Sphagnum: how Sphagnum-specific compounds compare to those of medicinal plants

Malak Tfaily, Jane Fudyma, Roya Amini Tabrizi, Hans Gieschen

Peatland ecosystems traditionally serve as carbon sinks, which by and large is due to the bryophytic moss keystone species, Sphagnum. Sphagnum is known to possess antimicrobial characteristics that suppress microbial activity and soil organic matter degradation, and therefore suppresses subsequent greenhouse gas emission. It is important to understand Sphagnum's antimicrobial nature, because as the climate changes across the globe, increased CO_2 concentrations and elevated temperatures are expected to increase graminoid abundances over a. These changes might increase the availability of labile C in the rhizosphere leading to higher CO_2 and CH_4 emission rates, eventually rendering peatlands as a carbon source. In this study, we compared ten known antimicrobial plants and their chemical composition to Sphagnum to obtain a better understanding of Sphagnum's antimicrobial compounds. Plant extracts were analyzed using Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FTICRMS) to identify the molecular weights and chemical compounds present in each of the samples. We hypothesize that sphagnum possess compounds similar in structure to those found in common medicinal and anti-microbial plants. The results will offer a stronger grasp on the link between structure and antimicrobial characteristics in Sphagnum, and will serve as a foundation for further research on Sphagnum's interaction with its microbiome.

Trevor McKellar, Graduate
The Drought Monitoring Guidebook: Using HYDRUS Modeling to Improve Drought Index Accuracy on Rangelands

Arizona's grasslands are an important ecosystem, managed for multiple uses, including forage for livestock, habitat conservation, and open space. Drought can impact grassland ecosystems in complex ways and land managers and livestock producers can benefit from drought monitoring strategies that help them anticipate and respond to changing drought conditions. Numerous drought indices based on temperature and precipitation anomalies or NASA satellite data, such as Soil Moisture Active Passive (SMAP) and MODIS Normalized Difference Vegetation Index (NDVI), are readily available to help managers and producers track drought conditions. These indices represent different aspects of hydroclimatic variability within soils and thus objectively identifying the index that best represents drought effects on grassland ecosystems and informs range management activities remains a significant gap for applying available climate information to land management actions. Addressing this gap requires development of an educational tool that successfully communicates to land managers which index best represents drought stress conditions of their rangeland into a comprehensive resource. This will be accomplished by developing a Drought Monitoring Reference Guide ("guidebook") that identifies key indices and triggers to anticipate potential drought impacts and inform management decisions. A soil moisture index created using high-resolution soil moisture modeling (HYDRUS-1D) will be compared with ground-based vegetation observations, traditionally used drought monitoring indices and remotely sensed indices to identify the optimal method that best represents soil moisture status on grasslands. These results will be summarized in the guidebook based on ecological site descriptions, which are extensively used by the rangeland management community today. This will allow for increased drought monitoring planning and decision making while removing the demand on users of needing to make complex interpretations between indices. Furthermore, this educational resource will help land managers make better use of NASA remotely sensed indices, such as SMAP and NDVI, and historical climate data to make informed decisions about managing their land.

Anissa Yvette McKenna, Graduate
Improved Methods of In Vitro Bioaccessibility Assessment of Toxic Metal(loid)s
Rob Root, Jon Chorover

Environmental contamination resulting from legacy mine tailings is a persistent problem due to elevated concentrations of toxic metal(loid)s. In semi arid regions, such as the Southwest United States, dry climate and lack of vegetative cover create conditions for these tailings to be transported off-site as fugitive dusts. This poses a considerable health risk to proximal communities who can experience exposure to these contaminants through incidental inhalation and ingestion of particulate matter. Previous work utilizing in vitro bioassays (IVBA) has shown that metal(loid) speciation is a factor controlling bioaccessibility. However, it is not clear whether this method accurately reflects bioaccessibility in vivo, because it does not account for changes in speciation due to in vivo variation in redox status, metabolic activity, and microbiome composition. I will present an M.S. thesis proposal for coupling abiotic gastric simulant in vitro bioassays (IVBA) with germ free and intact microbiome mouse models that will allow for the development of improved toxicological assays that can potentially relate biological toxic metal(loid) uptake and metabolic transformation with traditional laboratory release kinetics methods. Relevance of this work is supported by the high concentration of mines in Arizona, as well as the proximity of mine sites to indigenous populations in this region.

Josemaria Mollaneda, Undergraduate
Pore Water Chemistry of Mineral Dissolution Through an Intensive Steady-State Hydrological Event on an Incipient Basalt System
Yadi Wang

Incipient mineral dissolution during rock weathering has not been heavily studied in literature. The rate at which incongruent weathering of primary minerals to secondary minerals proceeds can be described by the cations present in the aqueous solutions that have passed through parent material over time. Previous studies have observed this occurrence at smaller scales in natural systems. At the University of Arizona Biosphere 2, the Landscape Evolutionary Observatory (LEO) consists of three large artificial hillslopes filled with tephra basaltic rock. Each hillslope is 11 meters in width, 30 meters in length, and 1 meter in depth and constructed with a total of 1881 above and below ground sensors. In this study, pore water samples from 496 prenart samplers spread along the length, width and depth of each hillslope were collected at the beginning, middle, and end of a periodic steady state (PERTH) experiment. Major elements, including Si, Al, Mg, Ca, P, Fe and Mn were quantified via ICP-MS at Arizona Laboratory for Emerging Contaminant (ALEC). The results of pore water chemistry will allow us to understand the spatial and temporal distribution of incongruency during primary basaltic minerals dissolution.

Mary-Madison Phillips, Undergraduate
Soil Carbon Additions in Pima County to Address Local Climate Change Resiliency
Joey Blankinship

Current atmospheric carbon dioxide (CO2) concentrations are soaring above 400 parts per million, leaving our growing human population desperately searching for solutions to avoid catastrophic impacts climate change. Policies are being implemented in order to help slow this change, but the answer of "how" has yet to be agreed upon. Pima County is currently exploring this "how" under terms of their 2018 Sustainable Action Plan to reduce its carbon emissions by 50% by 2025. Pima County aims to implement climate adaptation measures in its operations to support climate change preparedness and resiliency within five areas of focus: carbon (C), water, landscapes, materials, and workforce. Soil carbon addition can serve as a possible biogeochemical solution for capturing and sequestering C at a large scale; however, the specific types, application rates, and land use strategies of these C amendments have yet to be explored locally or quantified within Pima County. Compiling this information for three different carbon amendments— biochar, mulch, and compost— is critical in order to make soil a viable solution for addressing County climate goals. Our research seeks to quantify current County sites with and without carbon amendment practices to assess baseline soil C concentrations and the effectiveness of management practices in Pima County across croplands, rangelands, barren degraded lands, and County parks. Data were compiled from the existing scientific literature and on-the-ground measurements. This work will address the specific landscape goal of the Sustainable Action Plan to maintain or expand the number of County sites with composting and soil carbon amendment practices. Ultimately, the literary analysis and experimental results will become a critical component in achieving Pima County's goal of 50% reduction in carbon footprint by 2025.

Karen Serrano, Undergraduate

Biogeochemical Factors Affecting Phosphorus Availability During Revegetation of Mine Waste Rock SlopesLia Ossanna, Lydia L. Jennings, Julia W. Neilson, Raina M. Maier

Revegetation is an important aspect of degraded land recovery during mine site reclamation. However, it's often limited on mine waste rock due to factors such as poor nutrient status. One critical limiting nutrient is phosphorus, whose availability has been shown to be dependent on multiple biogeochemical factors. The specific aim of this study is to identify biogeochemical factors that influence phosphorus bioavailability (AP) as a soil quality indicator during the revegetation of mine waste rock. This study quantifies AP on hydroseeded and bare mine waste rock slopes undergoing revegetation at the Carlota Copper Mine. The parameters of pH, electrical conductivity (EC), DNA biomass, and the rhizosphere influence of shrubs and grasses will be explored individually and with reference to AP. Undisturbed areas on the mine set the standard for natural phosphorus availability. Data analysis revealed a significant difference in AP between the undisturbed areas compared to the waste rock. AP was significantly higher in the rhizosphere of shrubs than that of grasses within the waste rock. pH was significantly different among the waste rock slopes and undisturbed areas, but no difference was seen between the rhizosphere of shrubs and grasses. EC values were not significantly different between the waste rock slopes and the undisturbed areas. EC values were significantly higher in the rhizosphere of shrubs than that of grasses within the waste rock slopes. DNA biomass was significantly higher in the undisturbed areas than on the bare waste rock slopes; however, biomass on seeded waste-rock slopes was significantly higher in the rhizosphere of shrubs than that of grasses. Significant correlations were found between pH and AP as well as DNA biomass and AP. Analysis of the bioavailability of phosphorus on disturbed mining lands and the factors that impact it will aid in the recovery of the degraded land and in designing management strategies to enhance available phosphorus levels.

Jesus Solis-Leon, Graduate

Rainwater Harvesting: Prevalence of Metal(loid)s in Arizona Communities Adjacent to Toxic Release Sites Solis-Leon J 1, Moses A 1, Villagomez N 1, Anides A 1, Hegstrom C 4, Skelton N 5, Abrell L 1, Buxner S 6, Kilungo A 1,3, Mclain JE 1, Root R 1, Sandoval S 2, Sandhaus S 1, M Ramirez-Andreotta MD 1,3

As global warming exacerbates concerns of water scarcity, specifically in arid regions, rainwater harvesting has gained attention as a viable method by which dependence on existing water supplies may be offset. In partnership with the Sonoran Environmental Research Institute (SERI), Project Harvest (PH) – a co-citizen science project, has completed their first (2017-2018) year of sampling to determine the presence of potential contaminants in harvested rainwater of participating citizen scientists in Arizona communities; Dewey-Humboldt, Globe-Miami, Hayden-Winkelman, and Tucson. Sample collection required submission of water, soil, and plant materials during the two times of year in which precipitation, in Arizona, was most abundant; the winter and monsoon seasons. Though PH collects data on microbial, organic, and inorganic contaminants, only the latter will be discussed here for communities of interest. Based on neighboring potential sources of pollution, cistern type, and a literature review, aluminum (Al), arsenic (As), Cadmium (Cd), Copper (Cu), Lead (Pb), and Zinc (Zn) were the selected metal(loid)s of concern. Of the six elements, all but Zn had higher pervasiveness in harvested rainwater samples for the monsoon collection periods relative to winter rain samples. Peak concentrations of Al, As, Cd, Cu, Pb, and Zn were: 3,946 µg/L, 32.5 µg/L, 9.15 µg/L, 2,96 µg/L, 350 µg/L, and 951271 µg/L, respectively. Based on feedback about rainwater usage from participating communities, PH uses federal and state standards and recommendations on these elements to assess the usability of harvested rainwater for non-drinking purposes. The United States Department of Agriculture (USDA)'s recommended maximum trace element concentration for irrigation and livestock drinking waters as well as the full- and partial-body contact water standards set by the Arizona Department of Environmental Quality (ADEQ) were used to determine usability of harvested rainwater. Exceedances within the first year of PH included included As, Pb, and Zn for livestock drinking water and full-body water contact; Pb and Zn for partial-body water contact; and Zn for irrigation water standards. Findings of this study will inform implications on the science behind rainwater harvesting, practitioners, and communities involved.

Roya Amini Tabrizi, Graduate

Changes in Dissolved Organic Matter along a Permafrost Thaw Chronosequence in a Subarctic Peatland Malak Tfaily

The fate of carbon stored in permafrost-zone peatlands represents a significant uncertainty in global climate modeling. Given that the breakdown of soil organic matter (SOM) is often a major pathway for decomposition in peatlands, knowledge of organic matter reactivity under different permafrost regimes is critical for determining future climate feedback. To explore the effects of permafrost thaw and resultant plant succession on SOM reactivity, we used Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) to examine the SOM composition gathered from various sites along a permafrost thaw sequence in Stordalen Mire, a thawing subarctic peatland in northern Sweden. This impact of permafrost thaw on organic matter chemistry could intensify the predicted climate feedback of increasing temperatures, permafrost carbon mobilization, and hydrologic changes. In this study, we tested the hypotheses that organic matter reactivity increases with permafrost thaw due to thaw-induced subsidence and associated shifts in hydrology and plant community. Our study specifically addresses the effect of thawing permafrost, and its attendant shifts in hydrology and plant communities, on CH4 and CO2 production potentials and mechanisms, via changes in organic matter chemical composition (commonly referred to as organic matter "quality") in a thawing peatland complex.

Mira Theilmann, Undergraduate

Providing a Scientific Foundation for 2020 Colorado River Shortage Sharing Guideline Negotiations

Kathy Jacobs, Amanda Steinberg

Renegotiation of the 2007 Shortage Sharing Guidelines for the Colorado River Basin is rapidly approaching, and this river system, which is responsible for the water needs of nearly 40 million people, will require the integration of the sometimes competing needs of multiple stakeholders. The Colorado River Conversations project will assist in the development of a forum to engage scientists and stakeholders from a variety of technical and social science backgrounds in a series of discussions to create an interdisciplinary science foundation for renegotiation. Kathy Jacobs, the advisor for this Masters Project, has established the scope of the Colorado River Conversations through a funded proposal to the Walton Family Foundation. My Masters project will be based on the preparation of two background research papers, my assisting in development of the conference along with the advisory committee, and the production of summary materials following the conference. There are two tasks outlined in the project, the Colorado River Research Conference and future Scenario Planning workshops. The research conference will support the renegotiation effort and identify social and physical science gaps in establishing basin-wide management policies and the workshops will establish the conditions and consequences of extreme weather/climate scenarios on the basin. This project is an expansion upon two previously held conferences focused on garnering the input of scientists and water managers on how basin-wide management should proceed. Building bridges between water utility managers, climate scientists, water policy makers, and other stakeholders will result in greater integration of scientific information into policy design. Most importantly, the project will work towards expanding the focus of the negotiations themselves to include

a broader characterization of risk, and to include the consideration of biological, environmental, recreational, and social and cultural factors in the shortage sharing conversation.

Norma Nohemi Villagómez-Márquez, Graduate

Emerging Contaminants in Roof-harvested Rainwater for Irrigating Home Gardens in Arizona

Villagómez-Márquez, N1, Montijo, FJ1, Abrell, L1, Buxner, S1, Kilungo, A1,3, Mclain, JE1, Root, R1, Sandoval, F2, Ramirez-Andreotta, MD1,3

Roof-harvested rainwater (RHRW) can be one of the multiple alternatives and innovative methods that can help with our current water scarcity situation, especially in arid environments like the Sonoran Desert. However, nationally recommended standards for potable and non-potable domestic uses are yet to be established and as a result, the quality of roof-harvested rainwater is not well documented. Organic contaminants can enter rain and accumulate within a harvesting system from dust and aerosols that may deposit on roofs. In addition, the rainwater quality may decline during rooftop collection and storage due to the construction materials used for the harvest system and the roof surface materials. Four communities in Arizona are harvesting rooftop rainwater for non-potable uses such as home gardens. Over the course of three years, participants will collect rainwater, soil and plant samples and send them to be analyzed for bacteria, organic and inorganic contaminants at University of Arizona by our team of scientists. Project Harvest aims to generate data that will inform guidelines and recommendations for safe non-potable use of roof-harvested rainwater while empowering under-served communities in sustainable production of their own food sources. Harvested rainwater is both an ecological and viable alternative to combat water scarcity as it supports global water conservation, sustainability, and management of Earth's most precious resource. Herein the organic chemistry aspect of this project is described including sample preparation, analytical methodology, and year one results.

Yake Wang, Graduate

Transport of graphene in quartz sand and Vinton soil

Miscible-displacement experiments were conducted to investigate the transport and retention of graphene and graphene oxide in quartz sand and/or Vinton soil. Graphene was dispersed into water with a surfactant solution at a concentration of 2 mg/L. For graphene transport, the breakthrough curves exhibited typical colloid transport behavior, with breakthrough at 1 pore volume (PV) and steady-state irreversible retention. The relative effluent concentration plateau increased slowly towards 1, indicating the existence of a colloid blocking phenomenon. Greater retention was observed at lower pore-water velocity. Graphene oxide displayed a higher mobility compared to graphene. Greater retention was observed in the presence of SDBS versus Tween

Oral Presentations

Brian Agenbroad, Graduate
Drivers of Carbonate Accumulation in the Cordones Fanglomerate; Saddlebrooke, AZ
Craig Rasmussen

The accumulation of pedogenic carbonates is important to understanding carbon cycling, to include carbon sequestration, in arid and semi-arid regions. Carbonate accumulation in southern Arizona displays significant spatial variation, particularly in alluvial deposits that dominate basins in the region. Improved understanding of the controls on pedogenic carbonate accumulation is needed. We hypothesize that carbonate accumulation in alluvial fans is controlled significantly by parent material composition. To address this hypothesis, samples were taken from a chronosequence containing multiple buried horizons and carbonate accumulations. Parent materials include calcareous and non-calcareous meta-sedimentary rocks, diabase, granites and schist. Measurements included carbonate concentration using a traditional method of hydrochloric acid digestion. This was compared to results generated with an ATR FTIR spectral curve for calcium carbonate concentration. Bulk elemental content was obtained via XRF analysis for quantification of immobile element accumulation and ratios to be used as proxies for eolian deposition. Iron extractions (sodium dithionite and ammonium oxalate), quantified via atomic absorbance spectrometry, were taken as indicators for changes in weathering. Empirical dates were obtained via the uranium/thorium method to constrain carbonate accumulations and weathering regimes and to test for correlation to known climate shifts in the Pleistocene. Results indicate that a parent material low in the immobile elements titanium, zirconium and niobium is the dominant source for carbonate accumulation in the chronosequence.

Aidan Richard Foster, Graduate
Assessment of Soil Microbial Health by Near Real-time AMP/ATP Detection
Luisa Ikner, Ian Pepper, Erika Stark

Soil health is characterized by a number of physical, chemical, and biological properties. In particular, soil microbial communities are chiefly responsible for the cycling of carbon and nitrogen-based nutrients that are required to ensure optimal crop yields in agricultural settings. A myriad of cultural, biochemical and microscopy methods have been in practice for several decades to assess the levels of microbiological activity in soil. However, many are not capable of distinguishing the metabolic state of the microbes (e.g. active versus dormant). The objective of the current study involves the use of a near real-time assay to determine the metabolic status of soil microbial communities. Levels of adenosine monophosphate (AMP) and adenosine triphosphate (ATP) are measured, and the AMP to ATP ratio then calculated to determine the AMP Stress Index (AMPi) given changes in soil moisture content over time. Metabolically-active cells maintain an AMPi value of ≤ 1, whereas dormant or stressed communities demonstrate much higher AMP Indices of >10. In the current study, it was observed that AMP/ATP ratios drastically shift from high to low during soil rewetting cycles regardless of soil type in as few as four hours. The AMP Index assay provides a near real-time assessment of microbial activity compared to classical culture-based and biochemical soil health assays. The measurable shift of microbial metabolism for soil communities may better inform the necessity and timing of agricultural practices including irrigation, and the application of fertilizers and other growth factors.

Diego Huerta, Undergraduate
Analyses of Invasive Plant Phenology Data from the National Ecological Observatory Network and National Phenology Network
Katharine Gerst

Invasive plants can have substantial negative impacts on ecosystems by impacting fire dynamics, modulating nutrient cycles, and harming native species. Phenology, the timing of plant and animal life stages, is important for land managers attempting to control these plants, as treatment effectiveness often depends on species life stage. Knowledge of phenological patterns and climatic drivers of invasive species allows for improved control and predictions of future impacts. The USA National Phenology Network (USA-NPN) and National Ecological Observatory Network (NEON) both collect standardized phenological records of several invasive plants. We surveyed and compared available invasive species observation records within these databases. For select species, we constructed models to predict leafing and flowering onset date using key climate variables. These models provide insight into climatic drivers of phenology, and can be used to improve natural resource management strategies, including timing control activities, vulnerability assessments, and adaptation planning.

Lydia Jennings, Graduate
Microbial Bio-indicators of Degraded Soil Development on Reclaimed Mine Tailings in Southern Arizona
Lia Q.R. Ossanna, Mira L. Theilmann, Julia W. Neilson, Raina M. Maier

Mining activities generate unstable waste materials that frequently present environmental hazards to the health of neighboring communities and ecosystems. Mining reclamation aims to stabilize waste and restore affected land to a condition capable of growing self-sustaining plant communities. A critical limitation to vegetation success in mining waste is that these "soils" are deficient in the microbial communities essential to sustainable plant development. Soil microbial communities facilitate vital nutrient cycling for phytostablization and can provide a direct indication of soil ecosystem potential. We aim to improve revegetation strategies by working with mining companies to develop microbial indicators that quantify soil formation improvement during phytostabilization. Metadata including total DNA biomass, 16S rRNA bacterial gene abundance were quantified, in addition to chemical indicators such as total nitrogen, pH, and electrical conductivity, to identify temporal patterns that correlate with plant growth. This study analyzed four years of data from two tailings dams in Southern Arizona that revealed significant differences in soil biogeochemical indicators. Both total DNA biomass and 16S rRNA bacterial gene abundance showed significant temporal increases with successful plant cover. We contend that these metrics can be used to evaluate long term reclamation success on active mining sites in arid ecosystems. Improved understanding of the impact of microbial community capacity on reclamation success can facilitate the development of microbial technologies to enhance phytostabilzation-based mine waste stabilization, making reclamation more economical and effective.

Dorsey Kaufmann. Graduate

Communicating Environmental Data through Visual Art: A case control study

Monica-Ramirez-Andreotta, Ellen McMahon, Shana Sandhaus, Leona Davis, Nevan Madrid, Addison Kaufmann, Nima Hamidi

Challenges associated with communicating environmental data are affecting both decision-making and behavioral change. Although researchers have explored visualizing environmental data, the contribution of contemporary art to the topic is minimal. Visual art, which uses more emotive and personally relevant language, may help bridge the divide between scientific information and personal responsibility. Ripple Effect visualizes environmental data through an interactive art installation and aims to transform the way people understand their data in relation to their environment. Ripple Effect uses technology to translate Project Harvest rainwater quality data into sound waves. The installation consists of trays of water that sit on top of music speakers. Each speaker plays the soundtrack of the data, meaning participants hear and see the water vibrate based on the chemical concentrations in the rainwater samples. Lining each speaker is an LED light strip, which lights up each time the individual data points exceed the Maximum Contaminant Level set by the U.S. Environmental Protection Agency under the Safe Drinking Water Act.

A one page written survey instrument consisting of 3 questions with a Likert scale was administered to participants after they experienced Ripple Effect to capture participant's self-perception of engagement, understanding, and excitement to learn. The survey was also administered to a control group that received the same environment data, but contained in a booklet, without Ripple Effect. A total of 51 participants completed the survey. The mean response for Ripple Effect participant's level of engagement, understanding, and excitement to learn was 4.8, 4.7, and 4.9 respectively; whereas the control group's mean response was 4.8, 4.8, and 4.6 respectively.

Focus groups were also conducted within both visualization methods for qualitative data collection and analyses. 43% of the participants mentioned aspects of Ripple Effect were helpful in understanding the data, compared to 31% of the participants mentioned aspects of the booklet were helpful in understanding the data. Eight participants mentioned that Ripple Effect taps into visual/spatial learning, which benefited their learning experience. Five participants mentioned that Ripple Effect had a greater impact than viewing the same information graphically.

The results show that participants are impacted by experiencing environmental data through art and reported high levels of engagement, understanding and excitement. Though there are no major statistical differences by data visualization method, the qualitative data gives insight into how the participants described and experienced the data differently. This prompts further exploration into alternative means of communicating scientific data, as well as measuring immediate and long-term behavioral outcomes associated with environmental art.

Iliana Manjón, Graduate

Ingestion and Inhalation of Metal(loid)s Through Preschool Gardening: An Exposure and Risk Assessment in Legacy Mining Communities

Annika Alexander-Ozinskas, Allison Hacker, Christian Hegstrom, Nikki M. Lippert, Joanne Hild, Robert A. Root, A. Eduardo Sáez, Mónica D. Ramírez- Andreotta

Living near active and legacy extraction sites is of increasing concern for neighboring communities that rely on locally-grown foods. Children residing in legacy mining towns are potentially disproportionately exposed to heavy metal(loid)s via ingestion (of food, water, and incidental soil), and dust inhalation; thus, increasing their risk of exposure when engaging in school or home gardening or playing outside in non-garden, playground soil. The purpose of this citizen-science pilot study was to assess preschool children's potential metal(loid) exposure through these routes. Parents and teachers were trained on how to properly collect water, soil, and vegetable samples from their preschools throughout Nevada County, California. Arsenic (As), cadmium (Cd), and lead (Pb) concentrations in garden irrigation sources did not meet or exceed the US EPA Safe Drinking Water Act's maximum contaminant levels. The mean As concentration within garden and playground soil samples exceeded the US EPA regional screening level (RSL), CalEPA's California Human Health Screening Level (CHHSL) and California Department of Toxic Substances Control Screening Level (DTSC-SL). In contrast, Cd concentrations were below these recommended screening levels. Further, 35% of the garden and 13% of the playground soil samples nearly met or exceeded the EPA's RSL for Pb, while 61% of the garden and 53% of the playground soil samples nearly met or exceeded CHHSL and DTSC-SL for Pb. Metal(loid) exposure via homegrown produce revealed that lettuce and cabbage grown in the preschool gardens accumulated a higher concentration of metal(loid) than store-bought (USFDA Total Diet Study, 2006-2013) lettuce and cabbage analyzed form around the US. None of the vegetables exceeded the respective recommendation maximum levels for Cd and Pb set by the WHO's Codex Alimentarius Commission. Dust samples (<10-µm diameter) were generated from surface garden and playground soil collected at the preschools. Soil and dust samples were then analyzed by in-vitro bioaccessibility assays using synthetic lung and gastric fluids to estimate the bioavailable fraction of As, Cd, and Pb in the body. Lastly, a dietary assessment consisting of a 24-hour recall and food frequency questionnaire was administered to determine intake rates of foods shown to accumulate these contaminants. By conducting a comprehensive environmental monitoring and exposure assessment that includes child-specific dietary data, the average daily doses of contaminants through ingestion of soil, water, and vegetable and inhalation of dust can be determined to better inform risk assessment and public health interventions related childhood exposure to these metal(loid)s.

Denise Moreno Ramírez, Graduate

Voices Unheard: Preserving Oral Histories about Contaminated Sites in Arizona

Ramani Mejugas, Dr. Mónica Ramírez-Andreotta, Dr. Jamie Lee, Dr. Janick Artiola, Dr. Mark Nichter, and Dr. Raina Maier

It is necessary to listen to the stories of individuals as well as document local knowledge when it comes to environmental issues. The Voices Unheard: Arizona's Environmental History project recovers the historical accounts, descriptions, and insights from the people living near two contaminated sites in Arizona. One being the Tucson International Airport Area Superfund site that has been impacted primarily by a metal degreaser called trichloroethylene; and the second is the Iron King Mine and Humboldt Smelter Superfund site that contains mine waste with arsenic and lead. The Voices Unheard project draws on lived experience together with historical archival documents to tell more complex stories of health impacts and community advocacy. The oral histories have been video / audio recorded, then these histories have been transcribed, and the interviewees have provided photographs / artifacts that illustrate their history. The project combines environmental science, medical anthropology, oral history, and qualitative methods to implement a mixed approach and create a community-engaged platform. By encapsulating this environmental history, the project creates an invaluable and rich archive for today and for the future by establishing primary sources of public history that will be accessible online and at the local libraries. Most importantly, it is adding to the dominant history narratives of both areas and amplifying the voices of those who often go unheard.

Bryan Moravec, Graduate

Separating legacy from contemporaneous weathering in the critical zone

Alissa White, Rob Root, Jennifer McIntosh, and Jon Chorover

The critical zone (CZ) is the permeable, living skin on the Earth's surface where water, biology, lithology, and atmosphere interact in tightly linked processes that have co-evolved over geologic timescales. CZ processes and services are both a function of modern-day forcing (e.g. climate, energy inputs, etc.) and CZ structure that results from geologic transformations over time. Separating legacy geologic events (e.g., hydrothermal alteration, deposition, regional structural strain, etc.) from modern day CZ hydro-biogeochemical weathering processes is challenging in complex geologic terrains, yet quantifying the modern CZ (via weathering dynamics) that overlays an altered, legacy geologic canvas provides better understanding of CZ function and response to changes in climate (long term) and events (short term, e.g. fire). To investigate weathering processes in a legacy impacted CZ, we extracted three continuous cores to 40-50 m depth from an upland catchment of the Jemez CZO within the Valles Caldera National Preserve in northern New Mexico. The research goals were to understand geologic- and depth-dependent trends in the physical, chemical and biological structure, identify mineral transformations that result from hydrologic and biogeochemical dynamics, and describe lateral and vertical groundwater flow and its contribution to the geochemical evolution of the deep CZ. Results show complex weathering profiles at each of the three watershed positions attributable to a combination of legacy hydrothermal alteration, textural controls on weathering, development of preferential flowpaths, and differing hydrologic base levels. We used a multifaceted tool set to deconvolute the extent to which observed variation laterally and with depth resulted from legacy versus contemporary weathering processes. Co-located Ca-zeolites and smectite (up to 50% of bulk mineral composition) coupled with Mg, Fe, and Mn enrichment suggest legacy hydrothermal fluid intrusion contributed to mineral transformations in shallow portions (down to 15 meters) of the catchment east of a north trending fault bisecting the catchment and at depth (below 15 meters) west of the fault. Conversely, the presence of iron (oxy)hydroxides (up to 4%) coupled with calcite (17%), smectite (up to 49%), illite (up to 22%), absence of zeolites, and depletion of K, Na Si, and Ca in other portions of the catchment suggest contemporaneous glass, plagioclase and mica weathering is occurring at shallow depths and at textural transitions.

Arthur Moses Graduate

Every Last Drop: A Look at the Microbial Properties of Harvested Rainwater in Rural and Urban Arizona Communities

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The American Southwest has long been an area known to struggle with its water supply and drought. Population growth and climate change are exasperating the strain on water distribution systems. To mitigate this issue, community members are taking to the time-honored practice of harvesting rainwater and want to understand their water quality to use in home gardens. The University of Arizona's Project Harvest (PH), in partnership with the Sonora Environmental Research Institute, Inc. is a co-created citizen science project aimed at filling this informational gap. Participants in Hayden-Winkelman, Globe-Miami, Dewey-Humboldt, and Tucson, Arizona are submitting harvested rainwater and garden soil samples. Based upon historical climate and significant rain event data, samples are collected four times a year, at the beginning and end of both the monsoon and winter season. During 2017-2018, 198 microbial rainwater and 72 microbial soil samples (36 irrigated with rainwater; 36 non-irrigated) were collected. Harvested rainwater samples are analyzed for total coliforms and E.coli, using Colilert. Non-irrigated and irrigated (by rainwater) soil samples go through a presence/absence test for Salmonella and E.coli. The quantifiable average for total coliforms in the harvested rainwater samples was 331.02 CFU/100ml (n=105). There were 41 and 52 samples below the lower limit of detection (LLOD) and above the upper limit of quantification (ULOQ) respectively. For E.coli the quantifiable average was 169.54 CFU/100ml (n=36). There were 159 samples below the LLOD and none above the ULOQ. Each soil sample was run in triplicates using 0.25 g, 0.50 g, and 1.00 g of soil. Of the soil samples (n=215), Salmonella, E.coli, and both organisms were positively detected in 39.5%, 41.9%, and 27.9% respectively. These preliminary results indicate that there is likely a source for fecal contamination throughout common rainwater harvesting methodologies used by participants. Project Harvest participants, as well as other families who are harvesting rainwater, need to consider factors that may influence microbial growth in their water harvesting method, such as cistern material, roofing material, and the frequency of cistern cleanings. Conversely, families need to consider best practices for themselves to reduce microbial exposures. Next steps include an examination of whether these organisms are observed on the edible portions of food crops.

Christina Morrison, Graduate

Evaluation of naturally occurring viruses as indicators of integrated membrane system performance for water reuse application

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Advanced treatment processes are indispensable for mitigation of microbial and chemical contaminants in recycled waters within potable reuse systems. Integrated membrane systems, micro or ultra-filtration coupled with reverse osmosis (RO), are often implemented in advanced treatment processes due to their ability to remove molecular-sized particles such as viruses and chemical contaminants. Viruses are of particular relevance due to their acute health effects, low infectious dose, small size, and resistance to disinfection. Currently, studies on physical removal of viruses by RO membranes are scarce. The goal of this project is to investigate the removal of viruses in full-scale and pilot-scale RO processes implemented for water reuse applications.

Samples of RO permeate (1,000+ L) and treated wastewater effluent (1-100 L), used as feed water for the RO systems, were concentrated using virus adsorption-elution methods coupled with centrifugal ultrafiltration units. Quantitative polymerase chain reaction assays (qPCR) and quantitative reverse transcription PCR (qRT-PCR) were used for detection and quantification of virus genomes. Virus targets include adenovirus, pepper mild mottle virus (PMMoV), cucumber green mosaic mottle virus (CGMMoV), crAssphage, human bocavirus, as well as a newly discovered circular rep-encoding single stranded DNA virus (WCDV-2). These targets are found in treated wastewater at values of 10^2 to 10^7 genome copies (gc) per liter, on average. This study has detected PMMoV, WCDV-2, and CGMMoV in RO permeate at values of 5 – 50 gc per 100 L. The presence of these viruses in RO permeate streams highlights their potential for use as indicators of RO membrane integrity in full-scale reuse systems.

Yadi Wang, Graduate

The Role of Discharge Rate and Physical/Chemical Parameters on Incipient Basalt Weathering

Angela Sun, Mary Kay Amistadi, Peter Troch and Jon Chorover

Poorly-crystalline alluminosilicates are especially an important control on the composition of discharge water and therefore chemical equilibrium between the dissolving and precipitating phases determines the maximum concentration and maximum silicate weathering flux during the incipient basalt weathering process. Discharge rate, which implies the fluid residence time can often have a strong effect on the solution chemistry and mineral weathering. Previous studies found chemostatic relationship between discharge rate and solution concentration by using a standard method of passing discharge sample through 0.45 um filters without considering the presence of non-dissolved colloidal particles in solution. The concentration-discharge results therefore may mislead the understanding of chemical equilibrium and mineral weathering of a given catchment. To fully understand the impact of weathering mechanisms, only truly dissolved chemical composition within the discharge water should be considered. In this pilot study, we cascade filtered discharge samples of two rainfall events under different climatic conditions from the Biosphere 2 Landscape Evolution Observatory

(LEO) hillslopes through 0.45 um and 0.025 um filters. Solution chemistry of Si and Al show the presence of larger colloidal particles in solution during the warmer rainfall regime but non-significant during the cooler rainfall regime. The presence of these colloidal particles can strongly affect predicting mineral weathering. Results from this study could be used to better understand the concentration-discharge relationship and predict mineral weathering during an incipient process.

Lia Ossanna, Undergraduate

Nitrogen dynamics as an indicator of mine waste revegetation progress

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Hardrock mining is a crucial industry that has struggled to develop environmentally sustainable practices. During the process of closure, mines meet the challenge of using revegetation strategies to return heavily disturbed land into a productive ecosystem. This study focused on an open pit copper mine in central Arizona in the process of revegetating waste rock material as required by the National Forest Service. A direct revegetation strategy was used without applying a soil cap or amendments; hence, the waste rock must develop into a soil matrix with potential to support plant growth. The objective of this research was to identify belowground indicators of soil development that correlate with plant establishment, with a focus on how shrubs and grasses affect the nitrogen dynamics of a waste rock microbiome.

A comparative study was conducted of unseeded waste rock, seeded waste rock, shrub and grass rhizosphere-influenced waste rock, and natural ecosystem control samples. This research analyzed the status of the waste rock microbiome as a soil quality indicator because soil microbes are essential to nutrient cycling and soil fertility. Nitrogen was the focal nutrient because it is often limiting in semiarid ecosystems. Total nitrogen (TN) in the waste rock was low (48 ± 15 ppm), in comparison to the surrounding natural ecosystem (1164 ± 282 ppm). In contrast, TN of shrub rhizosphere-influenced waste rock (586 ± 194 ppm) was significantly higher than that of unseeded waste rock. The amoA gene was quantified to evaluate the functional nitrification potential of ammonia-oxidizing bacteria. Shrub rhizosphere-influenced waste rock had significantly higher amoA abundance than other types of waste rock, indicating shrubs assist microbiome development and create a fertility island effect. Strong positive correlations were observed between TN, DNA biomass, and amoA gene abundance, with high values associated with undisturbed soils and shrub canopies. In contrast, weak negative correlations were observed between NH_4^+ and TN, biomass, and amoA gene abundance. These results suggest that TN is a better nitrogen indicator of soil development than NH_4^+. Organic carbon and bacterial 16S rRNA gene abundance were also measured to quantify associations between organic matter content, bacterial abundance, and nitrogen dynamics. Soil quality indicators associated with revegetation progress provide critical tools for the mining industry to guide management practices that improve the effectiveness of revegetation efforts.

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