Undergraduate Research Symposium May 17, 2013 Mary Gates Hall

Online Proceedings

POSTER SESSION 1

Commons East, Easel 79

11:00 AM to 12:30 PM

Using Inexpensive Temperature Sensors to Estimate Incoming Radiation and Snow Surface Albedo

Adam Massmann, Junior, Civil Engineering
Mary Gates Scholar
Mentor: Jessica Lundquist, Civil And Environmental Engineering
Mentor: Mark Raleigh, Civil and Environmental Engineering

Over one sixth of the world's population, including 60 million people in the western United States, depends on snowpack for their primary source of water. Water resource managers use snow models to help quantify the amount of water stored as snow. Many modern models explicitly quantify how various methods of energy transfer affect snow ablation but are limited by a lack of in-situ observations for some forms of energy transfer. In particular, measurements of incoming radiation (one of the dominant sources of snow melt in many climates) and snow albedo (the fraction of solar radiation reflected by snow) are scarce due to the high cost of radiometers and the difficulties of obtaining quality measurements in mountainous terrain. Sensor windows are easily covered by heavy snowfall and require frequent maintenance. In contrast, small, inexpensive temperature sensors require minimum maintenance and are far less likely to be covered by snow. Their low cost and ease of installation allow for far greater numbers of observations. Because of this, we are exploring new methods of estimating radiation and albedo by deploying groups of temperature sensors purposefully shaded in different ways. Each group has one temperature sensor shaded from all radiation, one sensor shaded from downwelling radiation, and one sensor exposed to radiation from all directions. We hope to develop a reliable, inexpensive, and accurate method for calculating radiation and snow albedo from the difference in temperature readings between each sensor. Observed radiation at each study site will be used to engineer and validate the method. One year of measurements at Tuolmne Meadows, CA has been recorded and another recent installation at Snoqualmie Pass, WA provides additional data to include in our study.

POSTER SESSION 1

Commons East, Easel 78

11:00 AM to 12:30 PM

Arsenic Fate Post Sulfate Reduction: Assessing the Feasibility of Short-Term Groundwater Remediation Techniques for Arsenic Removal

Hunter Keane (Hunter) Brown, Senior, Civil Engineering
Mentor: Rebecca Neumann, Civil and Environmental Engineering
Mentor: Lara Pracht, Civil and Environmental Engineering

Arsenic-contaminated groundwater poses a major environmental hazard and adversely affects the health of over 100 million people worldwide. Prolonged consumption and exposure leads to arsenicosis, which can result in skin lesions, impaired cognitive development, cancer and death. One current groundwater remediation technique involves injecting microbial nutrients (i.e. sulfate and carbon) into the subsurface of contamination sites to promote the formation of minerals (through microbial-induced reducing conditions) that either integrate arsenic into their matrix or adsorb arsenic onto their surface. However, studies have shown that post-treatment arsenic levels can increase beyond pre-treatment levels if the predominant removal mechanism is adsorption, and if sufficiently high levels of organic carbon are present to further reduce the adsorbing minerals, resulting in the re-mobilization (release) of arsenic. Therefore, it is important to determine the dominant removal process in order to develop effective long-term remediation techniques. Presently, we are working to determine the effectiveness of techniques involving induced microbial sulfate reduction through nutrient injections, which are currently being used for arsenic removal near Tacoma, WA. To simulate field conditions I pumped contaminated groundwater, extracted from the site, through sediment test columns to determine the arsenic retention capacity of the system. Once effluent and influent arsenic concentrations matched, we used the method of sequential chemicals extractions, along with μXRF and μXRS (microscale x-ray fluorescence and absorption, respectively) to determine the speciation and prevalence of the various arsenic-utilizing and -adsorbing minerals created. Next, we will pump uncontaminated groundwater through the columns to determine the post-treatment concentrations expected for this site due to re-mobilization. If our results show that the dominate removal mechanism is the incorporation arsenic into precipi-

tates, preliminary treatment will be sufficient. However, if adsorption is the primary removal mechanism, a long-term treatment plan will need to be developed to minimize the re-mobilization of arsenic.

SESSION 2A

GRAPHS AND GEOMETRY

Session Moderator: Werner Stuetzle, Statistics
085 MGH
3:45 PM to 5:15 PM
* Note: Titles in order of presentation.

Classifying Freight Carriers in Supply Chains
Andrea Jeanne (Andrea) Gagliano, Senior, Business Administration (Finance), Mathematics
Mary Gates Scholar
Mentor: Anne Goodchild, Civil & Environmental Engineering

Computer-generated transportation models are used by State Departments of Transportation to simulate flows of goods and people on roadways. Infrastructure investments and policy decisions can be supported by results of these models. Passenger travel is well developed and uses activity-based models using characteristics of the household to more accurately model travel behavior. Freight, on the other hand, is not as developed, and uses simple algorithms to predict goods movement. This research focuses on characterizing freight travel in the context of supply chains to more appropriately model frieght behavior. A survey was conducted of motor carriers in Oregon and Washington to capture fleet statistics, carrier services, travel distances, time of day travel patterns, and company characteristics to find which factors differentiate motor carriers. The results revealed a key distinction between "Supply Chain Node Carriers" and "Only Transportation Carriers," with "Supply Chain Node Carriers" being split further into those companies linked to raw materials, manufacturing facilities, storage facilities, distribution centers, and retail outlets. Suggestions are made on how to implement these findings into state transportation model developments to enhance them. These more precise models allow for evidence-backed infrastructure investments and policy decisions.

POSTER SESSION 3

Commons East, Easel 62
2:30 PM to 4:00 PM

Development of Methods to Study Responses of the Earthworm Immune System to their Specific Symbiotic Bacteria and Foreign Bacteria
Kyuwoong Kim, Junior, Biology (Molecular, Cellular & Developmental)
Adrian Diaz Guerrero, Senior, Biology (Molecular, Cellular & Developmental)
Meghan Eileen Spain, Senior, Spanish, Microbiology
Mentor: Seana Davidson, Civil & Environmental Engineering

The goal of our research is to understand mechanisms of the earthworm immune system responsible for distinguishing symbionts from potential pathogens. The Hygiene hypothesis, proposed by David Strachan and published in British Medical Journal in 1989, fundamentally expanded our view on microorganisms and natural development of immune system. The hypothesis states that early childhood exposure to microorganisms is essential for acquiring healthy immunity. Studies in mice showing that host-specific bacteria in the gut are required for full maturation and function of the immune system support this hypothesis. Although numerous symbioses of beneficial bacteria with animals have been studied, the role of symbionts in the development of host immunity remains uncertain. Additional models are needed to study the roles and regulation of the immune responses to host-specific beneficial bacteria. The earthworm offers a tractable system in which to study immune system development and responses to both beneficial symbionts and potential pathogens. *Eisenia fetida*, a common composting worm, has an effective immune system that eliminates bacteria from the coelom. *E. fetida* also harbors specific bacterial symbionts in the excretory organs (nephridia) that process coelomic fluid, thus potentially exposing the bacteria to immune elements in the fluid. We hypothesize that the immune system adapts to the symbiotic bacteria in order to avoid eliminating them, or cause unnecessary inflammation in the nephridial tissue. Therefore, we investigated the contribution of the bacterial symbiont *Verminephrobacter eiseniae* to the development of immune system responses in *E. fetida*. Coelomocytes were extracted from symbiont-containing earthworms and symbiont-free earthworms, and were examined for differences in their binding and engulfment responses to *V. eiseniae* and non-symbionts. We believe further studies of the role of immunity in symbiont recruitment mechanisms in the earthworm would help us understand more about the co-evolution of beneficial microbiota and the host organisms in other species.

POSTER SESSION 3

Commons East, Easel 64
2:30 PM to 4:00 PM

Quantification of Ozone Formation during Sunlight-Driven Photolysis of Aqueous Chlorine
Shelby Sayuri (Shelby) Asato, Senior, Civil Engineering
Mentor: Michael Dodd, Civil and Environmental Engineering

Free available chlorine (FAC – generally comprising of hypochlorous acid and hypochlorite in aqueous solution at circumneutral pH) is currently the most common disinfectant in drinking water facilities around the world. Although the use of FAC is inexpensive and generally effective, some microorganisms that may be present in drinking water are recalcitrant to inactivation by the use of FAC alone. We are investigating the use of FAC photolysis by sunlight as a novel approach to enhancing the inactivation of such microorganisms. This process is known to generate atomic oxygen, which may react with dissolved oxygen to generate ozone -a much more effective disinfectant than FAC toward many microorganisms. Our studies have already indicated that the photolysis of FAC can enhance inactivation of highly chlorine-resistant B. subtilis spores (common surrogates for chlorine-resistant waterborne pathogens) through the generation of ozone. The main focus of the research to be presented addresses development of a method for in situ quantification of ozone formation during chlorine photolysis and its effects on the inactivation of B. subtilis spores. We are currently investigating the use of various probe molecules for this purpose, including cinnamic acid and vinyl phosphoric acid – each of which reacts selectively with ozone via Criegee ozonolysis; yielding stoichiometric quantities of benzaldehyde and phosphate, respectively, which may be quantified as measures of ozone exposure. Once validated, the use of such an approach would enable direct quantification of the ozone levels to which microorganisms are actually exposed during FAC photolysis, in turn facilitating the prediction of pathogen inactivation rates in treated waters.

POSTER SESSION 4

Balcony, Easel 96
4:15 PM to 5:45 PM

Wave Energy to Electricity: Maximizing Load Change for Ocean Wave Energy Conversion
Curtis John (Curty) Rusch, Junior, Mechanical Engineering
Mentor: Jim Thomson, CEE/APL

Waves carry a significant amount of energy, but this energy has not been thoroughly explored for human use. There are a myriad of different ways to harness this energy. One very promising method is through the vertical oscillation of a buoy as waves pass beneath it. The Applied Physics Lab (APL) has teamed up with Oscilla Power to test an APL buoy design paired with an Oscilla power generator. This pairing has been tested over a matter of months on Lake Washington, just off of Sand Point. The buoy itself is anchored to the bottom of the lake by three anchors, and a weight consisting of two railroad wheels hangs in the water column beneath the buoy. The Oscilla Power energy-generating device attaches mid-line above the hanging weight. There are a number of data acquisition devices onboard measuring the motion of the buoy via accelerometers, the loading on the tether, and electrical output of the Oscilla Power device. The results of this test show a relation between wave height and power output via tether loading, verifying the buoy design. Optimal power output coincides with optimal wave heights and frequencies, and the results of this test and subsequent data analysis reveal these values. This information is crucial to the design of future moorings for wave energy conversion devices. This work may be scaled up to provide power to open ocean research buoys, extending the battery life of these devices. If these tests are promising, additional uses for this energy on a larger scale could be explored.

POSTER SESSION 4

Commons East, Easel 76
4:15 PM to 5:45 PM

CESURA: Curved Element SUpported RAil
Lucas Whitesell, Junior, Civil Engineering
Mary Gates Scholar
Mentor: John Stanton, Civil Engineering
Mentor: Travis Thonstad, Civil and Environmental Engineering

As Seattle's light rail system expands, one branch is being designed to cross the I-90 floating bridge in order to connect downtown to Redmond. The challenges associated with designing a rail system over a floating bridge are significant. Traditional train rail systems are not built to accommodate the wide range of movements undergone by a floating bridge but Parsons Brinckerhoff have designed a new kind of rail called CESURA that will allow this new branch of Link light rail to exist. I have been helping to construct and test a full-scale replica of part of the CESURA system and my personal research has focused on the specific stiffnesses of the rubber fasteners which hold the rails to the rest of the system. These stiffnesses are very difficult to determine without a specialized test to isolate their properties. A hydraulic actuator was used to provide loads that would either rotate or linearly translate a rail that was secured by a single fastener. Various instruments were calibrated and placed throughout the system in order to monitor the fastener's behavior in response to different loadings. The newly discovered fastener properties will improve computer models of CESURA and allow Parsons Brinckerhoff to more accurately understand how the entire system behaves. Armed with this new knowledge Parsons Brinckerhoff will be better prepared for their next test in Pueblo, CO with an actual Link light rail train running over the full CESURA system.