Abstracts for 10th Annual Brace Day March 24 2011

13:45 Sogol Rasouli, Quantifying Nitrogen Export from Artificially Drained Agricultural Fields in the Pike River Watershed during Fall Rainfall Events, *Natural Resource Sciences*

14:05 Felexce Ngwa, A Multiplex Real-Time PCR for Early Detection of Toxigenic Cyanobacteria in Freshwater Bodies, *Bioresource Engineering*

14:25 Zian Sally, Community Water Supply Schemes: Ensuring that Progress towards the MDG for Water and Sanitation is Sustained, *Civil Engineering and Applied Mechanics*

14:45 Sarah Lebel, Hydrological Modeling of a Small Agricultural Watershed in India, *Bioresource Engineering*

15:05 Basanta Biswal, Do Wastewater Treatment Processes Impact the Virulence Risk of Escherichia coli? *Civil Engineering and Applied Mechanics*

15:25 Mohan Basnet, Stabilization and transport behavior of palladized zero valent iron nanoparticles in model groundwater environments, *Chemical Engineering*

15:45 Arti Bhakta, The Effect of Freeze-Thaw and Temperature Stress on the Transport and Survivability of Pathogenic Escherichia coli in Granular Porous Media, Depts. of *Civil Engineering and Chemical Engineering*

16:05 Adamo Petosa, Mobility of Metal Oxide Nanoparticles in Saturated Granular Porous Media: Influence of Water Chemistry and Particle Coating, *Chemical Engineering*

16:25 Anteneh Belayneh, Short-term drought forecasting in Ethiopia using wavelet-neural networks, *Bioresource Engineering*

16:45 Zeinab Hosseinidoust, Using bacteriophage to capture and kill food and waterborne pathogens, *Chemical Engineering*

17:05 Sylvana Hochet, Effect of Eucalyptus plantations on the hydrology of high Andean catchments, *Civil Engineering and Applied Mechanics – Water Resources*

17:25 Meysam Najari, On the Range of Applicability of the Piezo-Conduction Equation, *Civil Engineering and Applied Mechanics*

17:45 Simone Bourke, Calibration and Validation of DRAINMOD for Determining Vertical and Deep Seepage , *Bioresource Engineering*

18:05 Usman Khan, Understanding substance flows of morphine to the various national aquatic environments, *Civil Engineering and Applied Mechanics*

Quantifying nitrogen export from artificially drained agricultural fields in the Pike River watershed during fall rainfall events

Sogol Rasouli, Natural Resource Sciences

In southern Quebec, the Missisquoi Bay of Lake Champlain has become progressively eutrophic, as evidenced by frequent cyanobacteria blooms during summer months since 2001. Elevated nitrogen (N) concentration in the water is partially responsible for eutrophication in the Missisquoi Bay. Agricultural lands are the major source of N and other nutrients in the Pike River watershed, which drains into the Missisquoi Bay. Nutrient export occurs mainly through subsurface drainage during fall rainfall events. The objective of this study was to evaluate the N source: organic vs. mineral N fertilizer, and the N forms: nitrate (NO_3-N), dissolved organic N (DON) and particulate organic N (PON) in the subsurface drainage from agricultural fields (sandy and clayey soils) under annual crop production in the Pike River watershed, Quebec. Water samples were collected from tile drains at seven dates, between October to December 2010, and analysed for the natural abundance of $\delta\ ^{15}N$ and N forms. The $\delta\ ^{15}N$ values revealed organic residue as the major source of N exported in tile drainage, and greater organic N losses were found in sandy than clayey soils. The dominant form of N lost was NO_3-N (85% of total N), with smaller contributions from PON (10 % of total N) and DON (5 % of total N). In conclusion, manure N is susceptible to loss through subsurface drainage in fall, and the contribution of PON and DON to total N export is substantial after fall rainfall events.

A Multiplex Real-Time PCR for Early Detection of Toxigenic Cyanobacteria in Freshwater Bodies

Felexce F. Ngwa[a],* Chandra A. Madramootoo[a], Suha Jabaji[b]

[a] Department of Bioresource Engineering, McGill University, 21111 Lakeshore Road Ste. Anne de Bellevue, Québec, H9X 3V9

[b] Department of Plant Sciences, McGill University, 21111 Lakeshore Road Ste. Anne de Bellevue, Québec, H9X 3V9

Abstract

Increasing incidence of potentially toxic cyanobacterial blooms in fresh water bodies worldwide pose significant threats to human and ecosystem health. Potential microcystin-producing cyanobacteria constitute a major component of the cyanobacterial community in many lakes in Quebec (Fortin *et al*.2010). Detection of these noxious species by conventional methods has often been hampered by the co-occurrence of morphologically indistinguishable toxic and non-toxic strains within the same bloom.

In this study, a multiplex quantitative real-time polymerase chain reaction (qPCR) approach was developed for specific detection of three microcystin-producing cyanobacteria in a single reaction. Multiple oligonucleotide primers and probes were designed to target the microcystin synthetase gene E (mcyE) that encodes biosynthesis of the unique Adda moiety of microcystins in Anabaena, Microcystis, and Planktothrix species. Standard curves generated by relating toxigenic cyanobacteria concentrations to the threshold fluorescence cycle determined by the TaqMan assay were used to quantify microcystin-producing cyanobacteria in water samples from the Quebec portion of the Missisquoi Bay, Lake Champlain.

Preliminary results showed the developed assay to be highly sensitive, specific and reliable at detecting and quantifying targeted species. Indeed, the assay standards for the *Anabaena*, *Microcystis* and *Planktothrix* reactions attained efficiencies close to 100% with coefficients of determination of respectively 0.993, 0.992 and 0.995. All assays detected target toxigenic cyanobacterial strains in water samples when cyanobacterial cell numbers were still below the limit of detection for conventional detection methods**.** Thus**,** this robust method provides simultaneous detection, differentiation, and quantification of toxigenic cyanobacteria that otherwise cannot be accomplished by other currently used PCR assays.

Keywords: Cyanobacteria; microcystins; mcyE gene; multiplex qPCR; Taq nuclease assay

Community Water Supply Schemes: Ensuring that Progress towards the MDG for Water and Sanitation is Sustained

Mehdi Zian Sally[1], Susan Gaskin[2], Fidelis Folifac[2], Sunday Kometa[3], Lydia Lifongo[3]

[1] M.Eng Candidate, Dept of Civil Engineering, McGill University, Montreal, Quebec, Canada H3A 2K6
(+1) 514-243-9597, mehdi.sally@mail.mcgill.ca (corresponding author)
[2] Department of Civil Engineering, McGill University, Montreal, Quebec, Canada H3A 2K6
[3] University of Buea, Buea, Southwest Region, Cameroon

Abstract

Buea is a small urban area of 150,000 to 200,000 inhabitants, consisting of Buea Town and several villages arranged in a linear pattern along the main road descending the lower slopes of Mount Cameroon. Buea's location results in a variation of elevation and fairly abundant natural water resources. Despite this, the town is faced with a shortage of potable piped drinking water. The newly privatized water utility's network is outdated, too small, and is slow to be revamped, so the service gap has been filled by several small-scale community water supply schemes, funded by local residents, the municipal council, and NGO's. These schemes harness the flow from springs and distribute the water through a network of gravity-driven pipes. This study examines the challenges to ensuring sustainability of one such scheme, the Great Soppo, Wokoko, Molyko Community Water Supply Scheme serving rapidly growing communities on the lower slopes of the mountain. Due to interrelated reasons of (1) inadequate initial planning, (2) ineffective management, (3) lack of inclusion of the users in the management of the scheme, and (4) inadequate financing of operation and maintenance, the consequences are that demand has exceeded supply, flow of water is irregular, and users are forced to use alternative sources of water that are unsafe or expensive. The findings from this case study and the improvements suggested have important implications on ensuring Millenium Development Goal target of providing access to improved, safe sources of water is not just met at any point in time but sustained.

Hydrological Modeling of a Small Agricultural Watershed in India

Sarah Label, Bioresource Engineering

Water availability is influencing crop yields in the Padmalaya watershed in Central Maharashtra, India, which are below attainable yields. A number of rainwater harvesting structures such as on-stream check dams have been put in place, with the aim of improving water availability. The SWAT model was manually calibrated for hydrology using measured streamflow data from January to July 2010. Simulations were carried out for the period from 1977-2007 under various management conditions, with climatic data collected from the Jalgaon meteorological station. Future scenarios encompassing rainwater harvesting, climate change, land use change, and water conservation practices were evaluated, through 16 simulations to assess their impacts on these hydrological processes and crop yields for a 30-year period. Preliminary results show that on-stream structures significantly increase groundwater recharge. In addition, increased precipitation associated with climate change is likely to contribute to increased agricultural yields and crop water productivity. While the specific results from the simulations are limited to the Padmalaya watershed, the lessons learnt in terms of applicability of rainwater harvesting strategies in the context of climate change can be extended to similar agro-ecoregions of India.

Do Wastewater Treatment Processes Impact the Virulence Risk of *Escherichia coli*?

B. K. BISWAL,[1*] A. MAZZA,[2] L. MASSON,[2] D. FRIGON,[1] R. GEHR[1]

[1]*Department of Civil Engineering and Applied Mechanics, McGill University, Montreal, H3A 2K6*
[2]*Biotechnology Research Institute, National Research Council of Canada, Montreal, H4P 2R2*

The virulence risk of *E. coli* depends on the acquisition and/or expression of virulence genes which vary according to pathotype. This study evaluated the impact of biological and physicochemical treatment processes on the virulence risk of *E. coli*. As many as 90 *E. coli* isolates from each of the influent and undisinfected effluent samples from four wastewater treatment plants were characterized using DNA microarray technology to determine the impact of activated sludge (AS) or physicochemical treatment processes on the frequency of specific pathotypes, phylogenetic groups and antibiotic resistance genes in the *E. coli* population. The percentages of potentially pathogenic *E. coli* in the influent and effluent of one AS plant were 24% and 13% respectively whereas for another AS plant the percentages were 35% and 30% respectively. However, the percentages of potentially pathogenic *E. coli* in the influent and effluent of one physicochemical plant were 42% and 23% respectively whereas for another physicochemical plant the percentages were 30% and 17% respectively. The difference in pathogenic levels in the influent and effluent of the two physicochemical plants and one of the AS plants was significant ($P < 0.1$). The concomitant antibiotic resistance gene study revealed that 16% - 66% of *E. coli* isolates in the influent and effluent of each plant contained antibiotic resistance genes from the aminoglycoside, β-lactam, phenicol, sulphonamide and tetracycline groups. In conclusion, this study showed that both types of treatment processes reduced pathogenic levels in the *E. coli* population, but increased the level of antibiotic resistance genes.

Stabilization and transport behavior of palladized zero valent iron nanoparticles in model groundwater environments

Mohan Basnet, Subhasis Ghoshal and Nathalie Tufenkji
Department of Chemical Engineering, McGill University, Montreal, Quebec, Canada H3A 2B2, nathalie.tufenkji@mcgill.ca; tel. 514-398-2999.

Chlorinated solvents such as trichloroethylene are present as DNAPLs, or denser than water non-aqueous phase liquids, and these organic liquids can migrate deep into aquifers causing extensive contamination. Nanosized zero valent iron (nZVI) particles can contribute to the remediation of DNAPL source zones by transforming chlorinated organic compounds to innocuous products. However, we have a limited understanding of the transport and aggregation behavior of nZVI particles in DNAPL contaminated subsurface environments. In this study, we systematically investigate the influence of water chemistry and selected surface coatings and environmental molecules (e.g. biosurfactants) on the size and surface charge of bare and polymer-coated palladized nZVI particles using a number of complementary characterization techniques. We will present the results of characterizations, stabilization and macro scale transport experiments with an emphasis on the relative importance of different environmentally relevant surface coatings in stabilizing the nanoparticle suspensions.

The Effect of Freeze-Thaw and Temperature Stress on the transport and survivability of pathogenic *Escherichia coli* in granular porous media

A. BHAKTA [1] , S. GHOSHAL[1], and N. TUFENKJI[2]

[1] Department of Civil Engineering, McGill University, Montreal, Quebec, Canada H3A 2K6 [2] Department of Chemical Engineering, McGill University, Montreal, Quebec, Canada H3A 2B2
subhasis.ghoshal@mcgill.ca ;tel. 514-398-6867

Manure applied to agricultural soils contains pathogens that have the potential to travel through the soil and contaminate the groundwater supplies. In cold climate regions, surface and shallow sub-surface soil may undergo several freeze thaw-cycles during the winter. Microbial pathogens also tend to survive for long periods of time at low temperatures and are able to withstand severe environmental conditions. The environmental stresses may alter microbial characteristics and survivability and could provide conditions more conducive to their transport, as a result increasing the risk of groundwater contamination. Several studies have focused on the transport of microorganisms under various environmental conditions. However, there are very few studies examining the effect of freeze-thaw stresses on their transport and surface characteristics. In this study, we conducted laboratory scale column transport experiments with selected strains of *Escherichia coli* subjected to controlled freeze-thaw cycles as well as to long term incubation at 10^{o}C. Microorganisms subjected to freeze-thaw cycles were injected into laboratory columns packed with sand to obtain bacterial breakthrough curves. The differences in the breakthrough curves of the *Escherichia coli* strains subjected to different temperature regimes will be presented. The changes to cell viability, membrane damage and culturability of the *Escherichia coli* strains subjected to freeze-thaw cycles will be discussed.

Mobility of Metal Oxide Nanoparticles in Saturated Granular Porous Media: Influence of Water Chemistry and Particle Coating

Adamo R. Petosa, Spencer J. Brennan, and Nathalie Tufenkji

Department of Chemical Engineering
McGill University
3610 University St.,
Montreal, Canada
H3A 2B2

Abstract

Increased nanosized titanium dioxide (*n*TiO_2) and zinc oxide (*n*ZnO) use in commercial products will heighten the risk of their potential release into natural aquatic environments. The aim of this study was to improve our present understanding of metal oxide nanoparticle (NP) stability and mobility in natural and engineered water saturated granular systems. Laboratory-scale column experiments were performed with bare and polymer-coated *n*TiO_2 and *n*ZnO particles using columns packed with clean angular sand. Furthermore, multiple complimentary techniques were used to characterize the NPs under a range of environmentally relevant conditions: dynamic light scattering, nanoparticle tracking analysis, scanning electron microscopy and transmission electron microscopy. We also examined the effect of various preparation methods on suspension stability and particle deposition. Overall, uncoated (bare) NPs demonstrated high retention within the water saturated granular matrix and both bare *n*TiO_2 and *n*ZnO deposition onto sand was found to be dynamic (time-dependent). In addition, while bare *n*TiO_2 deposition behavior was in qualitative agreement with the Derjaguin-Landau-Verwey-Overbeek (DLVO) theory of colloidal stability at low ionic strength (IS), increased NP aggregation and physical straining within the granular matrix completely altered deposition behavior at high IS. In contrast to bare particles, polymer-coated NPs were highly stable in suspension and exhibited significant transport potential. The distinct behaviors observed demonstrate the need to consider both the extent and type of surface modification when assessing metal oxide contamination potential in granular aquatic environments.

Keywords: titanium dioxide, zinc oxide, nanoparticle, transport, nanoparticle tracking analysis, transmission electron microscopy

Short-term drought forecasting in Ethiopia using wavelet-neural networks

Anteneh Meshesha and Prof. Jan Adamowski , Bioresource Engineering

Abstract

Droughts are a normal and recurrent feature of climate, which cause significant damage to both the natural environment and to human society when they persist for a long period of time. Drought monitoring and forecasting play a significant role in mitigating the potential impacts of drought on the environment and in the planning and management of water resources. In this study, a method based on coupling discrete wavelet transforms (WT) and artificial neural networks (ANN) is presented for forecasting drought. Wavelet transforms have recently shown great ability in modeling and forecasting nonlinear and non-stationary time series in water resources engineering. Wavelet transformed data have been shown to improve model performance by capturing helpful information on various resolution levels. In this study, coupled wavelet-neural network models (WA-ANN) are applied to forecast drought, over various lead times, using the Standard Precipitation Index (SPI) series as a drought index in Ethiopia. SPI values were computed from monthly precipitation records from 1970-2005, which were provided by the National Meteorological Services Agency (NMSA) of Ethiopia. The performance of the coupled wavelet-neural network models (WA-ANN) will be compared to regular neural network models and to autoregressive integrated moving average models (ARIMA) to assess their potential to forecast drought over different lead times.

National Meteorological Services Agency of Ethiopia (NMSA)

P.O.BOX 1090
Tel. 251-1-512299/251-1-615779
Fax 251-1-517066
E-mail: nmsa@telecom.net.et
Addis Ababa, Ethiopia

USING BACTERIOPHAGE TO CAPTURE AND KILL FOOD AND WATERBORNE PATHOGENS

ZEINAB HOSSEINIDOUST[1], THEO G.M. VAN DE VEN[2], and NATHALIE TUFENKJI[*,1]

[1]*Department of Chemical Engineering, McGill University, Montreal, Quebec H3A 2B2, Canada*
[2]*Department of Chemistry, McGill University, Montreal, Quebec H3A 2K6, Canada*

* Corresponding Author. Phone: (514) 398-2999; Fax: (514) 398-6678; E-mail: nathalie.tufenkji@mcgill.ca

Waterborne infectious diseases bring death and illness to millions of people worldwide. Rapid, effective and sustainable methods to purify drinking water can save human lives in developing countries and in disaster scenarios such as floods or earthquakes. As natural predators of bacteria, bacteriophages can be used in water decontamination, food processing, and biomedical applications. Bacteriophages can be immobilized on substrates as simple as filter paper and serve as a means of water purification without need for any infrastructure. In this study, we have investigated the bacterial capture and inactivation capability of different phages. Five phages with different structures and genetic material were chosen and covalently immobilized onto a model substrate. The phage-functionalized substrates were subsequently tested for bacterial capture efficiency towards their host bacteria: *Salmonella typhimurium* and *Escherichia coli*. Furthermore, the rate of cell destruction for phage bound to the model surface was studied using fluorescence microscopy. The five selected phages (PRD1, P22, PR772, MS2, and T4) are representative of the possible structural variations for phages and allow us to evaluate the behavior of phages having completely different physical structure and mode of infection. Our results show that binding of the phages to the model substrate affected their biofunctionality as expressed by bacterial capture efficiency and rate of host destruction. Furthermore, the biology and surface properties of the phage and the bacterial target greatly influence bacterial capture and subsequent inactivation.

”Effect of Eucalyptus plantations on the hydrology of high Andean catchments”

Sylvana Hochet, Civil Engineering and Applied Mechanics – Water Resources

Abstract

Australia-native eucalyptus, a fast growing tree, is now widely cultivated in developing countries as a wood for construction and for its use in the pulp and paper industry. The eucalyptus –Eucalyptus Globulus- was originally introduced to Ecuador in 1865 and is now one of the predominant species in the Andean region. Although it is a source of rapid lumber, there is much controversy surrounding the culture of this invasive specie. The main concerns being its high water needs and its allopathic effects on the local flora. With receding glaciers, it is imperative to increase water conservation in this glacier water-fed region. To be able to efficiently address this issue, it is important to be able to properly quantify and understand the complicated relationship between the eucalyptus and its effects on the environment and more specifically, water balance. Data was collected in Riobamba, Ecuador, where water levels have been in an increasing deficit for the past 30 years. Infiltration rates, soil moisture content, porosity, relative humidity, evaporation, organic matter content, erosion and understory composition were compared between three sites: a eucalyptus forest, a 6-year-old patch of acacias planted within the eucalyptus forest, and a primary forest with the same altitude some 20 km away. The infiltration rates, moisture and organic matter contents were significantly lower in the eucalyptus forest, larger in the acacia patch and vastly superior in the primary forest. The desiccation caused severe erosion in the eucalyptus forest and due to this, the understory is now limited to cacti and other desert-favorable plants. The acacia patch showed more favorable conditions to plant growth and had wider species diversity in its understory. These experiments show that a monoculture of eucalyptus is not conducive to water conservation in a dry climate region such as the Chimborazo province in the Andes. It is also evident that a reforestation plan based on native plants could improve the soil properties of eucalyptus forests. This would lead to improved groundwater recharge and thus would have a positive impact on the water balance of the region.

On the Range of Applicability of the Piezo-Conduction Equation

M. Najari and A.P.S. Selvadurai
Department of Civil Engineering and Applied Mechanics
McGill University
E-mail: meysam.najari @mail.mcgill.ca)

ABSTRACT

The permeability characteristics of low permeability rocks are important to many geoenvironmental endeavours associated with nuclear waste management, geologic sequestration of carbon dioxide, the deep geologic disposal of toxic wastes, etc. The measurement of fluid flow characteristics of low permeability rocks is invariably performed using transient pressure pulse techniques, where the fluid is allowed to migrate into the low permeability region through a pressurized region in contact with it. The conventional analysis of the hydraulic pulse test is performed by employing the "piezo-conduction" equation, which describes the decay of the fluid pressure in the pressurized volume. The equation is characterized by a diffusion coefficient, which depends on the permeability of the porous medium, the compressibility of the pore fluid, the compressibility of the fabric of the porous medium and its porosity. The deformability of the porous medium in this formulation is accounted for only through the incorporation of the compressibility of the porous skeleton of the geomaterial. The more complete formulation of the hydraulic pulse test should take into consideration, the poromechanics modelling of the fluid-saturated geomaterial as proposed by Biot (1941). The objective of this presentation is to determine the conditions under which the solution to the pressure decay in a pulse test as determined from the piezo-conduction equation is a satisfactory substitute for the complete solution as determined by an analysis of the analogous coupled poromechanics problem based on Biot's model. The validation of the limits of applicability of the piezo-conduction equation is established by performing computational modelling.

Title: Calibration and Validation of DRAINMOD for Determining Vertical and Deep Seepage

Authors: Simone Bourke, Chandra Madramootoo

Water table management has been identified as a best management practice to reduce water loss and nutrient transport from subsurface drains. A better understanding of the soil-water interactions in the subsurface is needed to further assess the benefits and feasibility of such agricultural water management practices. The soil water balance is a comprehensive method of understanding soil water dynamics at the field scale. The objective of this study was to estimate vertical and lateral seepage by means of a soil water balance for conventional drainage and controlled drainage/subirrigation water management regimes in a 4.2 ha experimental agricultural watershed in south-western Quebec . The water table was either maintained at 0.6 m by a subirrigation system or was under conventional drainage at a drain depth of 1.0 m in a split block design with 12 plots over three blocks. Drainage, subirrigation, evapotranspiration, rainfall and soil moisture in the root zone were measured for the 2009 and 2010 growing seasons to determine the unknown components of the water balance. A field scale hydrologic model using DRAINMOD was then calibrated with daily water table observations for these seasons and validated for the 2004 and 2005 seasons. Simulations were compared to field measurements. Preliminary lateral and vertical seepage estimates will be presented.

Understanding substance flows of morphine to the various national aquatic environments

Usman Khan and Jim Nicell, Civil Engineering and Applied Mechanics

Sewer epidemiology is an emerging field that relies on the measured concentrations of select active pharmaceutical ingredients (APIs) in wastewater influents to estimate the prevalence of illicit drug abuse within the wastewater contributing community. However, for certain illicit drugs of abuse the most suitable marker compound may not only originate from illicit abuse of the drug but also from multiple licit sources. In particular, the suggested API marker for heroin, morphine can result from multiple licit sources. Hence, recognizing that from a sewer epidemiology perspective the main interest lies in quantifying the fraction of morphine that originates exclusively due to illicit drug use, it is important to compare the relative contributions of such a source to those that are expected to be realized through all licit sources. Further, by conducting such an analysis on a national level for many different countries, one can assess whether the sewer epidemiology approach for tracking the abuse of heroin is more feasible in certain countries than others. The primary goal of this communication is to precisely address such concerns. Results obtained suggest that in certain countries sewer epidemiology can be readily used to monitor the abuse of heroin, whereas in other countries consumption patterns of licit sources for relevant APIs are such that sewer epidemiologist are cautioned on exclusively relying on such a methodology.