Sixth Annual Brace Research Day
March 22 2007

10:05 Measurement of Net CO2 Exchange Using a Portable Profiling System, Pierre-Luc Lizotte, *Natural Resource Sciences*

10:25 Role of Natural Organic Matter on the Transport of Anthropogenic Nanomaterials in a Model Subsurface System, Andrew Pelley, *Chemical Engineering*

10:45 Global Warming Impact on Frost Injuries: New Developments for Risks Projection, Michel Baraaer, IWRM, *Bioresource Engineering*

11:05 Techniques for the Characterisation of Attached Nitrifying Biofilm, Robert Delatolla, *Chemical Engineering*

13:30 Impacts of Surface Runoff on Coral Reef Environments in Barbados, Marko Tosic, *Bioresource Engineering*

13:50 Statistical Modeling of Daily Streamflow Processes in Consideration of Climate Change, Stéphane Villemain, *Civil Engineering and Applied Mechanics*

14:10 Biogas from Organic Waste, Susan King, *Bioresource Engineering*

14:30 Quantifying Phosphorus Loss through Agricultural Subsurface Drainage Systems. Mark Eastman, *Bioresource Engineering*

15:05 Removal of Nutrients in Small Constructed Wetlands, Anne-Caroline Kroger, *Bioresource Engineering*

15:25 Effects of Oxidation-Reduction Potential (ORP) on the Solubility of Phosphorus, Yaqiong Hu, *Bioresource Engineering*

15:45 Optimization of a surface-flow constructed wetland for the treatment of agricultural runoff in colder climates, Charlotte Yates, *Bioresource Engineering*

16:05 GIS and Remote Sensing in the Sustainable Management of Sugarcane, Sohinee Mazumdar, *Bioresource Engineering*

16:25 Automated Landform Classification from Digital Elevation Model, Hossein Saadat, *Bioresource Engineering*

Pierre-Luc Lizotte
110142390
Department of Natural Resource Sciences

Title:
Measurement of net CO_2 exchange using a portable profiling system

Abstract:
In order to better quantify the continuous net ecosystem exchange (NEE) at the farm scale, a transportable tower-based eddy covariance and profiling system was tested during three field campaigns in summer 2006. The profile measurement system, equipped with a low-cost closed-path infrared gas analyser (LI-840) was designed to measure the carbon dioxide (CO_2) storage especially during weak mixing periods under stable conditions. The profile consisted of five inlet levels between the ground and a height of 18 m. The eddy covariance system was installed at a height of 24 m. A tethered blimp-based measurement system for the nocturnal boundary layer (NBL) budget technique was deployed on several calm nights to compare with the concentrations and fluxes determined with the profiling system. The NBL budget technique was used to quantify the portion of CO_2 storage estimated by the profiling system over the entire nocturnal boundary layer height. The profiling system was re-deployed for a portion of the campaign to determine horizontal and vertical advection. The two-dimensional horizontal positioning of the profile inlets allowed an examination of the CO_2 advective gradient in relation to the wind direction. A near-surface advection analysis provided parameters for further adjustments of the NEE at the actual farmland.

Role of Natural Organic Matter on the Transport of Anthropogenic Nanomaterials in a Model Subsurface System

ANDREW J. PELLEY, * and NATHALIE TUFENKJI

Department of Chemical Engineering, McGill University, Montreal, Quebec H3A 3R1

This project investigates the interaction between anthropogenic nanomaterials and mineral surfaces to predict the transport and fate of these particles within the saturated zone of groundwater aquifers. Given the widespread use of these novel materials, it will become practicably impossible to avoid the contamination of groundwater aquifers. It is imperative that the associated environmental risks be evaluated.

Interactions between colloids and subsurface sediment grains are highly dependent on the physicochemical and hydrodynamic conditions predominant in the subsurface environment and there exists a large body of research attempting to quantify these effects. However, the majority of this research has been limited to investigations of micron-scale colloids (e.g. clay particles, microorganisms, etc.) in highly idealized systems. The experimental systems used in the majority of transport studies have consisted of columns packed with model collectors (e.g. glass beads) under pristine conditions. Given the complex conditions present in natural groundwater, it is clear that investigation is required before conclusions drawn from model systems can be applied confidently.

One ubiquitous environmental variable influencing the behaviour of colloids in aquatic systems is the presence of natural organic matter (NOM). The term NOM refers to a large group of organic acids formed through the decomposition of plant residues and miscellaneous organic detritus. One of its roles in aquatic systems is that it tends to impart charge to suspended particulates, thereby influencing the stability and adsorption of colloidal suspensions. Given the recent advent of manufactured nanoparticles, determining whether generally accepted effects of NOM in aquatic systems are consistent for these novel materials is of interest.

The effect of NOM on the transport of both micron and nano-sized colloids was investigated using column transport studies. Experiments were conducted using glass columns packed with highly pure quartz sand over a broad range of physicochemical conditions. Suwannee River Humic Acid (SRHA) was selected to serve as a model NOM fraction as it has been well-characterized. A SRHA concentration (5 mg/L) representative of those found in groundwater systems was used in these experiments. Sulphate latex particles of both micron and nano-scale were selected to serve as model anthropogenic nanomaterials for transport studies. Latex particles of varying size and possessing similar surface charge density were selected to minimize physicochemical differences between the varying-sized particles. The surface (zeta) potential and size of the colloids was characterized both with and without NOM over the range of conditions used. Prior to each experiment, sediment grains and colloids were preconditioned with electrolyte in the presence or absence of NOM for approximately 24 hours. Experiments were performed under water-saturated conditions. Particle retention in packed columns was evaluated by monitoring the absorbance of effluent solutions using a UV-visible spectrophotometer and deposition kinetics, represented by the particle attachment efficiency, α, were determined.

Preliminary results indicate that there exists a transition between the attachment efficiency behaviour of colloidal suspensions at low versus high ionic strengths. At low ionic strength, the influence of NOM is sufficiently masked by the presence of very large electrical double layers, and there does not seem to be a significant effect from the presence of NOM. Conversely, at higher ionic strengths, electrical double layers have been sufficiently compressed that the presence of NOM did indeed seem to influence particle deposition kinetics.

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* Presenting author; andrew.pelley@mail.mcgill.ca

Global warming impact on frost injuries: new developments for risks projection

Michel Baraer[1]
Chandra A.Madramootoo[2]

Abstract

One of the most efficient techniques used to protect the buds, flowers, and fruits of apple trees against potentially damaging spring frosts, is by spraying irrigation water on the fruit trees via a sprinkler irrigation system. The purpose of this study was to evaluate the impacts of global warming on frost occurrences for the fruit growing conditions in Québec, with the long-term objective being to evaluate how this will alter amounts of water used for frost protection. Frost injury risk is characterized by using a phenological model coupled with a risk index generator. There is not yet a consensus in the literature regarding the type of phenological model that should be used for climate change impact studies. By consequences a model selection procedure has been developed to identify amongst a group of models those which exhibited ability to maintain a satisfactory level of accuracy when tested under different climatic conditions. Based on meteorological and phenological observations on apple trees in the Monteregie region of Québec, different validations stages provided evidence of the ability of the selected method, based on original phenological and risk index generator models, to reproduce and predict frost injury risk trends. Local climatic conditions downscaled from a GCM were used to assess the effects of future climate scenarios on the risk of frost injuries. Under the tested scenario, the risk index increases significantly, suggesting that the number and / or the severity of spring frost injuries would increase in the future. This would imply that the use of a sprinkler system as a protection method against frost injuries has to be taken into consideration for the assessment of climate change impacts on overall water demands for crop water requirements.

[1] MScA Candidate; Brace Center for Water Resources Management, Faculty of Agricultural and Environmental Sciences, McGill University, 21111 Lakeshore Road, Montreal, Québec H9X 3V9; Michel.Baraer@mail.mcgill.ca
[2] Dean of the Faculty of Agricultural and Environmental Sciences and Director of the Brace Center for Water Resources Management, McGill University, 21111 Lakeshore Road, Montreal, Québec H9X 3V9; Chandra.Madramootoo@mcgill.ca

Techniques for the Characterisation of Attached Nitrifying Biofilm

Robert Delatolla*, Dimitrios Berk, Nathalie Tufenkji

Department of Chemical Engineering, McGill University, Montreal, Quebec H3A 2B2

Nitrification is the biologically mediated oxidation of ammonia that occurs in many natural environments and also within wastewater treatment plants. Nitrification is characterised by slow growing nitrifying bacteria that have commonly demonstrated little or no growth below 4°C. Notwithstanding an overwhelming collection of evidence that points to a lack of nitrification at low temperatures, there exists field evidence and theoretical support that shows nitrification processes have the potential to achieve ammonia removal at low temperatures if the nitrifiers exist in the form of biofilms. These films can exist in wastewater treatment systems such as Biological Aerated Filtration (BAF) systems where the biofilm is grown on a fixed substratum. The ability to analyse biofilms, as they exist within these systems, is therefore the key to studying nitrification at cold temperatures. In this work, we propose the use of several microscopic techniques to study the structural and ecological characteristics of biofilm as it remains attached to its substratum.

Current advances in Confocal Laser Scanning Microscopy (CSLM), Environmental Scanning Electron Microscopy (ESEM), Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) have facilitated the analysis of biofilms. Although, these techniques show promising results with respect to analysing biofilm that has been removed from its substratum, the ability to use these techniques to investigate attached biofilm remains unproven. Thus, the objective of this work is to demonstrate the ability of current microscopic techniques to study nitrifying biofilms without removal of the biofilm from its substratum. The primary advantage of examining attached biofilm is that the destructive effects of the removal process, such as biofilm loss, biofilm contamination and distortion of in-situ perspective of the biofilm is eliminated. The study of nitrifying biofilm is believed to be well suited to direct analyses of the attached film without detachment because of the relatively small thickness of nitrifying biofilm.

This work demonstrates how the combined microscopic techniques of ESEM and CLSM in combination with Fluorescent In-Situ Hybridization (FISH) provide a detailed analysis of attached biofilms without the need for removal from the substratum. Surface images provided by ESEM allow the structure of the biofilm to be characterised in terms of the percent biofilm coverage and thickness. Three-dimensional images provided by CLSM in combination with FISH allows for the characterisation of biofilm ecology with respect to the type of bacteria present in the biofilm, the distribution of colonies within the biofilm and the number of cells within the biofilm. Thus, the total of these techniques offers a comprehensive understanding of the structural and ecological properties of biofilm attached to a substratum.

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* Presenting author: robert.delatolla@mail.mcgill.ca

Impacts of Surface Runoff on Coral Reef Environments in Barbados,
Marko Tosic, *Bioresource Engineering*

Nearshore pollution from surface runoff is a known factor leading to the degradation of coral reefs, and has been suggested to have contributed to the degradation of reefs in Barbados. Increased turbidity restricting the passage of light to the substrate and smothering due to sedimentation restricts coral growth. Surface runoff was monitored for various storms during the wet season of 2007 in Barbados. Monitored water levels and velocity profiles were used to calculate discharge, while grab samples were taken and analyzed for turbidity, total suspended solids, nitrates, and phosphates. Discharge data was used to calibrate a hydrological model, TR-55, while the concentration of effluents has lead to estimates of pollutant loads. Following storms, the nearshore reef waters were sampled for turbidity and total suspended solids to better understand the passage and time of dispersion for this pollutant input.

Title: **Statistical modeling of daily streamflow processes in consideration of climate change**

Author: Stéphane Villemain

Supervisor: Professor V.T.V. Nguyen

Date: Thursday, March, 22nd, 2007

Abstract:

Water resource planners need to develop contingency plans to deal with the potential impacts of climate variability and changes in the frequency and magnitude of riverflows. Studies suggest that warmer winter seasons, causing earlier runoff from snowpacks, and high variability of summertime flows in the tributary streams could adversely affect the water supply, water quality and agriculture production. Planning studies requires thus detailed information regarding the variability of streamflows for current as well as for future periods in the context of uncertain climate changes. Recently, General Circulation Models (GCMs) have been recognized to be able to represent reasonably well the main features of the global atmospheric circulation for the current climate and could produce details of future climate conditions for different climate change scenarios. Hence, there is a need to develop tools that could describe accurately the linkage between large-scale GCM climate simulations to the historical observations of the streamflow process at a local site of interest. If this linkage could be established, then the projected change of climate conditions given by a GCM could be used to predict the resulting change of the selected streamflow characteristics for hydrological impact studies. The required linkage can be developed using a wide range of statistical downscaling methods.

In view of the above-mentioned issues, this study is therefore concerned with the development of statistical models that could describe accurately the relations between large-scale climate predictors and local flow characteristics. These models are based on the application of linear regression methods to link historical streamflow data with historical climatic predictors at the daily scale as well as on the use of stochastic autoregressive modeling techniques to describe the dependence of successive daily flows. The proposed models were tested using NCEP-re-analysis data, Canadian GCM (CGCM) climate simulation data, and available historical observed streamflow series for the Eaton river basin in Quebec, Canada. Results of this numerical application have indicated that it is feasible to link large-scale climate variables with local flow conditions using a statistical downscaling method. In particular, the combined regression-autoregressive model with log-normal random noise could provide accurate description of observed statistical daily flow properties at the study site. The proposed model could then be used to assess future streamflow conditions from CGCM outputs for different climate change scenarios.

Biogas from organic waste

By Susan King

Abstract

Municipal, industrial and agri-food operations all produce organic waste. These waste products are rich in nutrients and frequently have a high water content. Traditional disposal of these wastes by landfilling and land spreading results in extensive pollution of ground and surface waters by nutrient-containing leachate and run-off. In addition, spontaneous anaerobic microbial activity in these materials releases methane (CH_4) to the atmosphere, contributing to the greenhouse effect.

When organic wastes are treated by controlled anaerobic digestion prior to disposal, there are numerous environmental benefits: methane is captured for use as a carbon-neutral energy source, reducing demand for fossil fuels and decreasing greenhouse gas emissions. Residual organic matter has enhanced fertilizer value due to the conservation of nitrogen, reduction of the carbon to nitrogen ratio, and the potential for precipitation of phosphorus compounds. Pathogen populations in the raw waste are reduced or eliminated, depending on the process conditions, and odours associated with land spreading are significantly reduced.

Anaerobic digestion has been used to produce fuel in situations where fossil fuels are either unavailable or extremely costly, for example in post-WW2 Europe and in developing countries such as India, China and Nepal today. However, producers generally see waste treatment as an activity with cost but no economic benefit, and resist implementation of such facilities unless required by legislation. The continued availability of fossil fuels at prices that do not reflect the environmental costs of producing and using them also masks the urgency of bringing alternatives into common use. When populations and governments are ready to take action on these issues, anaerobic digestion will be recognized as an excellent means of both producing “green” fuel and protecting our water resources.

Quantifying Phosphorus Loss through Agricultural Subsurface Drainage Systems

M. Eastman*, A. Gollamudi, C.A. Madramootoo, N. Stämpfli

Phosphorous (P) concentrations exceed water quality guidelines in most of the major rivers in Southern Québec. This problem is particularly noticeable in the Pike River, which drains into Missisquoi Bay of Lake Champlain. Lake Champlain is the sixth largest inland water body in the United States of America. It mainly lies in the states of New York and Vermont, but a small fraction of the lake extends into Québec; known as Missisquoi Bay. Each summer since 2001, Lake Champlain has experienced eutrophication and cyanobacteria outbreaks. Outbreaks are most prominent in Missisquoi Bay due to its shallow depth, and excessive P loading from the adjacent watershed. The use of Missisquoi Bay as a source for recreation and drinking water is limited during cyanobacteria outbreaks, which results in economic hardship for the region.

Non-point source pollution from agricultural regions has been identified as the principal source of P loads in Québec. While it is recognized that P loss from agricultural fields is mainly a function of surface runoff and soil erosion, a limited number of studies have found that P concentrations in subsurface drainage effluent often exceed water quality guidelines. To further study this relationship, two subsurface drained agricultural fields were instrumented in the year 2000 and two additional, characteristically similar, non-drained fields were established late in the year of 2004 to serve as comparison sites. One field from both the subsurface drained sites and the non-drained sites has clay soil, and the other two sites are loam soils. Data for the first complete hydrologic year (October 2005 – September 2006) suggests that P loss through subsurface drainage systems is highly dependent on soil texture and structure.

Total-P loss from the clay field practicing subsurface drainage was 72% greater (4.7 kg/ha) than the non-drained field (1.3 kg/ha). In comparison, total-P loss from the loam field was 2% greater (0.81 kg/ha) under subsurface drained conditions. Total-P load from the non-drained, loam field was 0.79 kg/ha. Particulate-P accounted for 82% (2.0 kg/ha) and 31% (0.127 kg/ha) of the total-P exiting the fields through the subsurface drains on the clay and loam fields, respectively. These results suggest that agricultural subsurface drainage systems are a preferred pathway for P transport, especially through clay soils and the dominant form of P transporting through the drains is particulate P.

In general, the clay fields, either subsurface drained or not, increased total-P loss. However, soil texture and structure are not the only variables responsible for P loss. Variables such as soil P concentration, P-saturation levels, slope, crop grown and fertilizer/manure rate and timing are important considerations. It is difficult to assess all of these variables in the field, therefore the field data will be used to calibrate the Soil and Water Assessment Tool (SWAT) in order to analyze all of the variables. SWAT is a hydrologic and water quality model that is capable of simulating the ability of various beneficial management practices at reducing P loss from both surface runoff and subsurface drainage.

* Presenting Author

Nutrient removal in a small constructed wetland

A.C. Kroeger, C. A. Madramootoo
Department of Bioresource Engineering, McGill University

Phosphorus contamination of surface waters is particularly problematic in agricultural watersheds of southern Québec. A constructed wetland under seasonal operation was investigated for retention of nitrogen and phosphorus inputs from stream water. The constructed wetland (1215 m^2) was supplied via a pipeline system with naturally flowing water from a first order stream draining mostly agricultural lands. The stream exported high nutrient loads to a vulnerable water body downstream. Hydraulic and nutrient loading rates to the constructed wetland were highly variable, with peak loading rates occurring in runoff events. Over 4 years of operation, the wetland retained 34 % of phosphorus inputs of 24.3 kg and 19 % of $N\text{-}NO_3^-$ inputs of 1276 kg. Average retention rates were 49.2 g NO_3^- m^{-2} $year^{-1}$ and 1.7 g total phosphorus m^{-2} $year^{-1}$. This study provides additional support for the use of small constructed wetlands as nutrient traps under diverse flow regimes in cold climates.

The Effects of Oxidation-Reduction Potential (ORP) on the Solubility of Phosphorus

Yaqiong Hu, Dr. Chandra Madramootoo

Bioresource Engineering

In previous field studies, results showed that phosphorus (P) concentrations and loads increased under water table management (WTM) compared to conventional free drainage. The suspected reason is that under WTM, anaerobic conditions are induced and, dissolved reactive phosphorus (DRP) is released into the water due to the reduction of Fe (III) and Al (III) phosphates to more soluble Fe (II) and Al (II) forms. The two major factors that control the solubility of minerals in soils are the pH and oxidation-reduction potential (Shenker *et al*., 2005). The objectives of this research are:

(i) To understand how P is released or broken down into its constituent forms under WTM.
(ii) To determine the effects of oxidation-reduction potential (ORP) on the solubility of phosphorus.
(iii) To simulate the oxidation-reduction potential (ORP) for different soils and water table conditions in a lab experiment.

In order to theoretically explain and quantify the effects of oxidation-reduction potential (ORP) on P solubility, field experiments and lab experiments were conducted. The research field is located in Coteau-du-Lac, about 50 km west of Montreal. In the field scale, solubility of P was compared under water table management (WTM) and conventional free drainage. In the lab experiment scale, the rate of variation of ORP and the effects of ORP on the solubility of P under different reducing condition were determined.

The field experiments show that pH is much higher under WTM than in free drainage; ORP is much lower under WTM than in free drainage; concentration of soluble P has the same trend as the pH; and dissolved Fe and Mn are much higher under WTM than in free drainage, while dissolved Al is almost same either under WTM or in free drainage. With an increase in the amount of glucose, lab experiments on the top soil (0-25cm) show that pH is decreased; ORP is decreased; concentration of soluble P is increased; and dissolved Fe & Mn are increased. Changes in dissolved Fe are much higher than dissolved Mn; there are no changes in dissolved Al.

In this study, both in the lab experiment at the top soil (0-25cm) and in the field experiment, there is a good correlation between the change in soluble Fe and the change in soluble P. The parallel increase in soluble Fe and soluble P suggests that the reduction and solubilization of ferric Fe compounds caused a subsequent release of Fe-P from the soil into the equilibrium solution; increases in soluble Mn also were correlated with the change in soluble P that suggested that Mn may control P solubility in some systems. However at the bottom soil, 25-50cm and 50-75cm, there is no correlation in either Fe or Mn with the changes in soluble P. Changes in soluble P were not significantly correlated with changes in soluble Al, either in the top and bottom soil or in the field experiment suggesting that Fe-P and Mn-P may be more important in this system.

Optimization of a surface-flow constructed wetland for the treatment of agricultural runoff in colder climates.

Charlotte Yates, *Bioresource Engineering*

Using constructed wetlands (CWs) for the purpose of wastewater treatment has been gaining popularity in the last 20 years. CW designs seek to take advantage of the natural processes that occur within natural wetlands to reduce or remove contaminants present in wastewater. We are seeing them employed in conjunction with conventional wastewater treatment plants as well as stand alone systems to treat point source wastewater streams from such sources as municipal, industry and agriculture. In more recent years, researchers have been investigating the use of CWs for treating non-point source pollution. The goal of this project is to optimize the effectiveness of a pilot-scale engineered constructed wetland in reducing nitrogen and phosphorous from agricultural run-off water in Southern Quebec.

The constructed wetland site is located near the Arboretum on Macdonald campus and starting in late August of 2006, the tanks were flooded continuously for 30 days with an artificial runoff wastewater containing 10mg/L nitrate-N and 0.3mg/L orthophosphate. The design is six open plastic tanks, three replicates of a field soil, and three replicates of a sandy soil. Each tank has a volume of $6m^3$ with 70% occupied by soil. At the inlet end of the tanks there is a deep zone from which the soil slopes upwards to the shallow zone. The shallow zone is vegetated with alternating sections of reed canary grass and cattails and the water flows from the deep zone, through the vegetated section to the outlet.

We are assessing the effectiveness of the sandy soil versus the clay field soil in removing N and P from the wastewater by monitoring the inflow and outflow concentrations from each tank. Water samples from the outflow of the tanks were collected every four days and analyzed for nitrate-N and orthophosphate during the month of September, 2006. Gas samples collected every five days from four different areas of each tank were tested for nitrous oxide emission as an indicator of denitrification activity. Preliminary results for September show that the nitrogen output was reduced by 37% in the sandy soil tanks and 43% in the clay field soil tanks. Nitrous oxide emissions were not detected throughout August or September however after adding 20 mg/L of carbon for the first part of October, we detected nitrous oxide levels above ambient concentration in four of the tanks, thus suggesting carbon had been rate limiting for the denitrifying bacteria. We predict that the growing season of 2007 will yield improved nitrogen reduction as plant detritus from 2006 should provide sufficient carbon to sustain denitrification.

Abstract:

GIS and Remote Sensing in the Sustainable Management of Sugarcane

Sohinee Mazumdar
Bioresource Engineering

According to the United Nations, the declining state of the world's freshwater resources will be the dominant issue on the environment and development agenda of the coming century. Agriculture, and its accompanying irrigation, accounts for more than 70 per cent of global freshwater withdrawals. As these withdrawals increase at an unprecedented rate, water scarcity poses the single biggest threat to global food production. In addition, the expansion of worldwide cropland faces crucial limitations, as an estimated 10 million hectares is lost each year to erosion and salinization. We must therefore improve agricultural efficiency by coaxing increased productivity from each parcel of cropland and by wisely using each liter of water. The cornerstone in the solution to this pressing problem lies in improved resource management.

Fortunately, the use of spatial information technologies over the last few decades has led to unprecedented sophistication in resource management. Space technologies, such as earth observation satellites, have greatly enriched our understanding of natural and human-driven processes. One of the greatest areas of advancement has been in agriculture, where the advent of remote sensing technologies and Geographic Information Systems (GIS) has revolutionized the field of Precision Agriculture (PA). Precision Agriculture involves the optimal management of agricultural inputs, such a freshwater, in order to minimize environmental impact and increase economic efficiency. Instead of applying pesticide, fertilizer or freshwater uniformly over a full field, we can use spatial information technologies to characterize environmental heterogeneity and hence apply agricultural inputs site-specifically. This has the potential advantage of increasing long-term and whole-farm productivity and profitability while decreasing negative impacts on the environment.

Although there has been success with various crops, considerable work remains to be done in the correlation of spectral information with crop and soil condition characteristics. This research is particularly important for ecologically harsh (input intensive) crops such as sugarcane, and for areas in which soil conditions are considerably degraded by salinization. This research project addresses these issues by establishing the groundwork for precision agriculture implementation at the Santa Rosa sugarcane plantation in the Republic of Panamá. The project involves building local capacity in GIS, data collection and ultimately sustainable agricultural management practices. This presentation will focus on the building blocks of Precision Agriculture implementation at this site, as well as some of the practical challenges and economic issues encountered during implementation.

Automated landform classification from digital elevation model

Hossein Saadat, *Bioresource Engineering*

Abstract

The study of landforms plays an important supportive role in developing soil, land use and soil erosion maps. The Iranian Soil and Water Research Institute (SWRI) has been involved in mapping the soils of Iran and classifying landforms for the last 60 years. Based on the results presented in the authors' paper, the accuracy of traditional landform maps is very low (about 55%). To-date aerial photographs and topographic maps are used for such landform classification studies. The principle objective of this research is to propose a unique qualitative approach for landform classification based solely on a 10 m resolution DEM and some use of an Aster image. In order to extract and identify automatically the various landforms an effort was made to use slope, elevation range and stream network pattern as basic identifying parameters. These are available for extraction from a DEM. Further, Aster images were required to identify the general outline shape of a landform type and the presence or absence of gravel. It is usually the landforms that have low slopes, such as River Alluvial Plains and Piedmont Plains that are the most difficult to differentiate via automatic digital approaches. To aid such classifications it was found that these landforms with overlapping and relatively flat slope characteristics could be separated into three distinct categories based solely upon polygon size and elevation range data. This study encompassed a relatively large watershed of 451,183 ha with a total elevation difference of 2,445 m which included a variety of landforms from flat river alluvial plains to steep mountains. Classification accuracy ranged from 91.80 to 99.59% with an average of 96.66% based upon extensive ground-truthing. Since similar digital and Aster image information is available for Iran an accurate landform map can now be produced for the whole country. The main advantages of this approach are accuracy, lower demands on time and funds for field work and ready availability of required data for many regions of the world.