45th Central Canadian Symposium on Water Quality Research

Program Schedule and Presentations

Sunday, February 21st, 2010

	CCIW Main Boardroom (L205)
14:00 to 19:00	CAWQ Board Meeting

Monday, February 22nd, 2010

7:45	Main Mall	• Registration • Poster Installation
	Auditorium	
8:30	Opening Remarks: Dr Ron Droste (President of the CAWQ)	
8:35	Welcome to the National Water Research Institute and Introduction of Plenary Lecture: Dr. Chris Marvin (Programme Chair and Vice-President for Ontario Region of the CAWQ)	
8:45	CAWQ Plenary Lecture: Dr. Susan Watson: Harmful Algal Blooms - Facts, Fiction and Fixes	

	Auditorium Wastewater: Investigations, Evaluations and Advances Chair:	Seminar Room Harmful Algal Blooms and Nutrient Issues Chair: Sue Watson	
9:30	The Reductive Degradation of the Medium Priority CMP Dye Acid Blue 129: A Potential Wastewater Treatment Approach S. Shirin and V. Balakrishnan	What causes a shift in dominant phytoplankton species in eutrophic waters? Lewis Molot, G. Li, Sue Watson, Andrew Paterson & David Findlay	
9:50	Evaluation of Model Parameter Sets for the Prediction of Activated Sludge Production M-A. Labelle, P.L. Dold, A. Gadbois, D. Lamarre, S. Deleris, P. Mathieu, Y. Comeau	Algal Blooms in Ontario Lakes J. Winter, L. Nakamoto, K. Utsumi	
10:10	Removal of Nitrate - Nitrogen From Wastewater Will Cost Millions, Achieve Little, and May Be Detrimental to Lake Winnipeg J. Oleszkiewicz and N. Szoke	Ontario Ministry of the Environment – Blue Green Algae Response Protocol Andrew Morley et al	

Time			
10:30	**Health Break** - Main Mall		
	Auditorium **Wastewater: Investigations, Evaluations and Advances** **Chair:**	**Seminar Room** **Harmful Algal Blooms and Nutrient Issues** **Chair: Sue Watson**	
10:45	Mapping and CFD Analysis of Multi-Lamp Photoreactors for Aqueous Degradation of Metronidazole M. Mohajerani, M. Mehrvar, F. Ein-Mozaffari	The Effects of Past Industrial Damage and Current Urbanization on Phytoplankton Communities in Freshwater Lakes J. Bradley, W. Keller and C. Ramcharan	
11:05	Sensitivity Analysis for Trash and Grit Removal from Activated Sludge by Microscreening and Hydrocycloning to Reduce Sludge Production M. Mansour-Geoffrion, P.L. Dold, D. Lamarre, A. Gadbois, S. Deleris, Y. Comeau	Eutrophication Risk Assessment in Hamilton Harbour: System Analysis and Evaluation of Nutrient Loading Scenarios Alex Gudimov	
11:25	Enhanced Activated Sludge Dewaterability by Applying Direct Current (DC) Field S. Ibeid, M. Elektorowicz, J. Oleszkiewicz	Characterization of Cylindrospermopsin chlorination by-products S. Merel, M. Clement, A. Mourot, V. Fessard, O. Thomas	
11:45	Comprehensive Wastewater Treatment Plant and Sludge Pretreatment Model É. L. Bordeleau and R. L. Droste[2]	TBA	
12:05	Diverse Anammox Communities Discovered in Contaminated Groundwater Environments Tara Moore and Josh Neufeld		
12:25	**Lunch** - Main Mall	**CAWQ Annual General Meeting - Seminar Room**	
12:30	**Poster Session** - Main Mall		

	Auditorium Occurrence, Fate and Relevance of Contaminants in Aquatic Systems Chair:	Seminar Room Harmful Algal Blooms and Nutrient Issues Chair: Sue Watson	
13:25	Identification of Nonpoint Sources of Fecal Water Pollution by TaqMan® Real-Time PCR Assays Using Bacteriodes 16S rRNA Genetic Markers <u>D-Y Lee</u>, S. Weir, H Lee, J.T. Trevors	**Forum to identify and discuss practical approaches to Alagal Bloom Risk Management** • **What is available to predict, detect and evaluate these blooms (tests, kits, monitoring devices etc.)?** • **What are the major practical and technical problems? And how might they be resolved?**	
13:45	Design and Validation of Oligonucleotide Primers for the Development of a Standardized QPCR Protocol to Detect Waterborne Bacterial Pathogens <u>S.T. Clark</u>, K.A. Gilbride, M. Mehrvar, A.E. Laursen, V. Bostan, R. Pushchak, L.H. McCarthy		
14:05	Application of Multivariate Statistical Tools in Biological Early-Warning Systems (BEWs) for the Detection and Identification of Specific Classes of Contaminants <u>A. Maradona</u>, M. Mehrvar, R. Pushchak, L.H. McCarthy, A. Laursen, V. Bostan, K.A. Gilbride		
14:25	Assessment of the Environmental Release and Eco-Toxicological Relevance of Illicit Drugs <u>U. Khan</u> and J. Nicell		
14:45		Health Break - Main Mall	
	Auditorium Occurrence, Fate and Relevance of Contaminants in Aquatic Systems Chair:	Seminar Room Harmful Algal Blooms and Nutrient Issues Chair: Sue Watson	
15:00	Cloning of *cry 1* and *cry 4* genes from native <u>*Bacillus thuringiensis*</u> isolated from the Western Ghats of Kerala P.M. Neema, R.D. Tyagi, D. Girija		

15:20	Potential Contribution of Micro- and Mesofauna to Phosphorus Release from Fish Farm Sludge M-L de Boutray, J. Puigagut, F. Chazarenc, Y. Comeau		
16:00	**Poster Session** – Main Mall		
18:00	**RECEPTION** **at Emma's Back Porch Pub** **2084 Old Lakeshore Rd. (5 minute walk from Travelodge Hotel)**		

Tuesday, February 23rd, 2010

07:30	Main Mall	• Registration	
	Auditorium **Emerging Threats to Drinking Water** **Chair: National Network on Environments and Women's Health**	**Seminar Room** **Geospatial Modeling** **Chairs: Wayne Forsythe and Chris Marvin and Analysis of Contaminant Distributions**	
8:20	The Gendered Health Effects of Chronic Low-Dose Exposure to Chemicals in Drinking Water Susanne Hamm	Watershed-Scale Imperviousness Extraction Employing Spatial-Based Metrics P. Luciani	
8:40	An Emerging Threat: Privatization and Commercialization of Water in Canada Patricia Hania	Geospatial Modeling of Pharmaceuticals in the Saint Lawrence River Basin G. Grill, U. Khan, B. Lehner, J. Nicell	
	Auditorium **Water Science and Water Policy: Interfacing with Community Organizations** **Chair: Bob Sneyd**	**Seminar Room** **Geospatial Modeling and Analysis of Contaminant Distributions** **Chairs: Wayne Forsythe and Chris Marvin**	
9:00	Two Muskoka Examples of Input into Public Policy Judi Brouse	Geospatial Distribution of Metal Contaminants in the Buffalo River A. Gawedzki and K.W Forsythe	
9:20	Volunteer Data Collection David Sweetnam	GIS-Based Analysis of Mercury and Lead in Surface/Subsurface Sediments K.W. Forsythe and P.S. Rodriguez	
9:40	Grassroots Community Engagement: Towards an Integrated Policy Approach Natalija Milicevic	Use of GIS-Based Kriging in the Design of Great Lakes Sediment Surveys C. Marvin and K.W. Forsythe	
10:00		Health Break - Main Mall	

	Auditorium Water Science and Water Policy: Interfacing with Community Organizations Chair: Bob Sneyd	Seminar Room Environmental Modeling Chairs: F. Ahmed and T. Bolisetti	
10:20	A view from the Ontario Nonprofit Network Lynn Eakin	Elucidation of Ecosystem Attributes Using Ecopath with Ecosim (EwE): Application to an Oligotrophic Lake in Hokkaido, Japan M. Monir Hossain, T. Matsuishi and G. Arhonditsis	
10:40	New Approaches to Environmental Decision-Making: Involving Stakeholders in the Risk Analysis Process H.C. Simpson and R.C. de Loë	Numerical Modeling of Hydrodynamics and Tracer Dispersion in Lake Winnipeg J. Zhao, R. Yerubandi, L. Wassenaar	
11:00	Broadening Participation in Policy Analysis Carolyn Webb	Calibrated and Physically Distributed HSPF Model for Rural and Urban Watersheds S.M. Bahar	
11:20	**Panel Discussion** **Water Science and Water Policy: Interfacing with Community Organizations**	Integration of Mathematical Modeling and Bayesian Inference for Setting Water Quality Criteria in Hamilton Harbour, Ontario, Canada M. Ramin, S. Stremilov, T. Labencki, A. Gudimov, D. Boyd and G.B. Arhonditsis	
11:40		Use of Models in Watershed Management F. Ahmed	
12:00		Sediment and Nutrient Loading from Big Creek Watershed, Ontario I. Wilson and T. Bolisetti	
12:20	Lunch - Main Mall	WQRJC Editorial Board Luncheon	
13:30	Presentation of Philip H. Jones Award - Auditorium		
14:00	Concluding Remarks - Auditorium		

Geopsatial Modeling and Analysis of Contaminant Distributions

45th CENTRAL CANADIAN SYMPOSIUM ON WATER QUALITY RESEARCH

CAWQ ACQE

Canadian Association on Water Quality
Environment Canada

Leadership in Water Science

FEBRUARY 22 & 23, 2010
Canada Centre for Inland Waters | Burlington | Ontario

GIS-Based Analysis of Mercury and Lead in Surface/Subsurface Sediments

K.W. FORSYTHE[1][1] AND P.S. RODRIGUEZ[1]

[1] Department of Geography, Ryerson University, 350 Victoria Street, Toronto, Ontario, Canada M5B 2K3

Surface and subsurface sediment core data were used to model the geographic distribution of mercury (Hg) and lead (Pb) within a section of the Buffalo River Area of Concern (AoC). Ordinary kriging was utilized to generate concentration prediction maps. Standard maps reveal prediction surfaces for the entire study area, while spliced maps show prediction surfaces for three sub-sections of the study area. The sub-sections were then merged to create a quasi-continuous surface. The latter type of map was needed in order to account for the pronounced meandering nature of the river and to reveal regional and local Hg and Pb sedimentation patterns. The results of this research show that there is a trend in Hg and Pb contamination that increases from the east towards the west (the direction of river flow), with a peak of high values in the mid region of the study area. Moreover, surface sediments are less polluted than subsurface sediments for both contaminants. Hg contamination is less widespread but more concentrated compared to that of Pb. Finally, this study highlights several contamination hotspots, which should be the target of any future sediment restoration endeavours in the AoC.

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Geospatial Distribution of Metal Contaminants in the Buffalo River

A. GAWEDZKI[1,2] AND K.W. FORSYTHE[1]

[1] Department of Geography, Ryerson University, 350 Victoria Street, Toronto, Ontario, Canada M5B 2K3

In the Great Lakes Water Quality agreement between Canada and the United States, the Buffalo River is listed as an Area of Concern (AoC). Three major contributors (ExxonMobil Corporation, Honeywell Corporation, and PVS Chemicals) to natural resource damage in the Buffalo River are being pursued for damages by the State of New York. This study analyzes the surficial sediment metal contamination of arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc within a section of the Buffalo River. The kriging spatial interpolation technique as implemented in the ArcGIS Geostatistical Analyst was utilized to generate areal prediction maps of contamination. The research suggests that there is a relationship between sediment contamination in the Buffalo River and potential pollutant contributions from the above mentioned corporations. Specific sections of the river that are located in the vicinity of the three corporations exceed sediment quality guidelines in terms of the Threshold Effect Level (TEL) and the Probable Effect Level (PEL) as defined by the Canadian Council of Ministers of the Environment (CCME).

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Geospatial Modelling of Pharmaceuticals in the Saint Lawrence River Basin

Günther Grill[1], Usman Khan[2], Bernhard Lehner[1] and Jim Nicell[2]

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Recent monitoring studies have confirmed that certain pharmaceutically active compounds (PhACs) are present in the Canadian environment. However, essentially all monitoring studies have three important limitations that should be addressed. First, in such studies, out of necessity only a few PhACs have been selected for study. Second, of the chemicals selected for monitoring, these studies can only report those contaminants that occur in concentrations that exceed the detection limits of the analytical methods used. Third, and perhaps mostly importantly, such studies span very limited spatial and temporal scales, with often only a few surface water samples being collected for analysis directly downstream of selected wastewater treatment plants. Therefore, in order to better grasp the relevance of PhACs in the environment as a whole, theoretically sound geospatial fate models have an invaluable role to play. Besides addressing the inherent shortcomings of monitoring studies mentioned above, geospatial models also facilitate in the identification of "contaminant hotpsots" within a particular catchment, therefore pragmatically directing future monitoring studies. Hence, the focus of the current investigation was to develop a geospatial contaminant fate and hydrology model of the Saint Lawrence River Basin. Runoff estimates were based on the global hydrological model WaterGAP; the original coarse scale estimates were spatially downscaled and routed along a high resolution river network. A local validation of the derived discharges was performed using HYDAT monitoring data. The contaminant fate application of the model for PhACs will be demonstrated using carbamazepine as a case study, comparing predicted concentrations of carbamazepine to what have been reported by monitoring studies in the catchment. The current limitations and expected refinements of the model will also be presented.

Emerging Threats to Drinking Water

The Gendered Health Effects of Chronic Low-Dose Exposure to Chemicals in Drinking Water

Susanne Hamm, National Network on Environments and Women's Health, York University

NNEWH's research confirms that Canadians do not have equal access to safe drinking water, when considered in a long-term health context. This research examined the long-term health risks of chronic low-dose chemical exposures in Canadian drinking water sources from a gendered perspective. Currently, a gendered analysis is largely absent from research on water resources and related policy documents on drinking water in Canada. Environmental health research on low-dose exposure to chemical contaminants increasingly points to critical windows of vulnerability for women. These windows of vulnerability relate to developmental and reproductive phases, which are gendered in nature. Recent research also indicates that exposure, susceptibility and absorption of specific contaminants may be influenced by gender.

The project adopted a case study approach that was based upon four contaminants (i.e., lead, TCE, nitrate and tritium) and selected Canadian communities (for example, London, ON, Shannon, QC, Abbotsford, BC and Pembroke, ON). Official municipal drinking water data was used as the primary source of analysis. The report does not offer a comprehensive review of the state of Canadian tap water quality or of drinking water systems across the country. Rather, in light of recent environmental health research, the report highlights a gap in access to safe drinking water and the need to adopt a precautionary approach to address uncertainties in the drinking water standard setting process.

The results of this study should be used to inform policy making on relevant standards and other regulatory aspects of the Canadian drinking water supply.

An Emerging Threat: Privatization & Commercialization of Water in Canada

Patricia Hania, National Network on Environments and Women's Health

In North America, privatizing water can involve transferring full control of water supply networks into the hands of private corporations by fully divesting assets through public flotation (i.e. when common stocks or shares are offered to the public), through direct sales, or through private-public-partnerships (P3s). Increasing private sector involvement in water supply networks all over the world has been accompanied by a rise in the application of commercial principles to water systems. This commercialization of water means private sector norms which center on profit-making and maximized efficiency are emphasized. While traditional government-run water utilities often subsidize prices for consumers in hopes of attaining social equity, many private and publicly-owned water systems today are choosing to adopt this commercial approach to water pricing.

Most research shows that when governments decide to enter into partnerships with the private sector for the provision of drinking water, it results in detrimental public health effects, and that women are particularly likely to be adversely affected. The cost and availability of water has implications for women in Canada, both in terms of their own personal health, and because women are very often primary caretakers, responsible for caring for the structural and health needs of their families and community. A gendered analysis of privatization should be considered by policy makers but is often absent. This research will contribute to the present gap in the privatization debate.

Harmful Algal Blooms

Eutrophication Risk Assessment in Hamilton Harbour: System Analysis and Evaluation of Nutrient Loading Scenarios

Alex Gudimov, Centre for Environment, University of Toronto

Environmental modeling has been an indispensable tool of the Hamilton Harbour restoration efforts, where a variety of data-oriented and process-based models have been used for setting the water quality goals by linking management actions with potential ecosystem responses. The former models are mainly steady-state; mass balance approaches that predict lake total phosphorus concentrations as a function of lake morphometric/hydraulic characteristics, while the latter ones are founded upon a mathematical depiction of biogeochemical processes that summarize the state of knowledge in limnology. In this study, the objective is to develop a biogeochemical model that can effectively depict the interplay among the different ecological mechanisms underlying the eutrophication problems in the Hamilton Harbour. First, there is provided the rationale for the model structure adopted, the simplifications included, and the formulations used during the development phase of the model. Then the results of a calibration exercise are presented with examination of the ability of the model to sufficiently reproduce the average observed conditions of the Harbour along with the actual ecological processes and cause-effect relationships in the system. With the shift in focus from how far we have come to how far we have left to go, the author attempts to address the following questions: What is the current status of meeting the objective of delisting the study system as Area of Concern? What additional monitoring is required? What is the likelihood of meeting the water quality targets? How fast are we getting there? In this regard, the present modeling study undertakes an estimation of the critical nutrient loads in the Harbour based on acceptable probabilities of compliance with different water quality criteria (e.g., chlorophyll a, total phosphorus). The model suggests that the water quality goals for TP (17 μg L^{-1}) and chlorophyll *a* concentrations (5-10 μg L^{-1}) will likely be met, if the Hamilton Harbour RAP proposition for phosphorus loading at the level of 142 kg day^{-1} is achieved. The author also provides evidence that the anticipated structural shifts of the zooplankton community will determine the recovery rate as well as the stability of the new trophic state in the Harbour. The author also discusses the next enhancements of the Hamilton Harbour model and concludes by pinpointing the weaknesses of the conventional model “training” practices (i.e., mere adjustment of model parameters until the discrepancy between model outputs and observed data is minimized). Finally, the presented study emphasizes the importance of calibrating the present model with Bayesian inference techniques that can rigorously quantify the uncertainty associated with model structure and parameters.

Algal blooms in Ontario lakes

JENNIFER WINTER, LYNDA NAKAMOTO AND KAORU UTSUMI

Sportfish and Biomonitoring Unit, Water Monitoring and Reporting Section, Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Toronto, Ontario, M9P 3V6

The Ontario Ministry of the Environment provides an algal identification service as part of the Ministry’s response to algal bloom events. We’ve been tracking the samples that have come into our group since 1994. Over the period from 1994 through 2009, we noted a significant increase in the number of algal bloom samples received each year ($P < 0.001$). There was also an increase in the number of samples in which cyanobacteria were confirmed to be dominant ($P < 0.001$), with these samples making up approximately 50 % of the total during peak years. The most common genera of cynobacteria identified were *Microcystis*, *Anabaena*, *Oscillatoria* and *Aphanizomenon*. The remaining samples were dominated by chrysophytes in particular, filamentous green algae, or occasionally by dinoflagellates or diatoms. We also noted geographic and seasonal trends in the bloom samples submitted. Most of the increase in the number of cyanobacterial bloom samples was accounted for by samples from lakes in northern Ontario (located within the boundary of the Ministry’s northern region). Samples are now coming in for analysis later into the fall than they did during the 1990s; bloom identification requests extended well into November in recent years. We will explore these trends in our presentation, and will outline several case studies conducted by our group in lakes experiencing recurrent algal blooms to evaluate the factors contributing to bloom development.

Characterization of cylindrospermopsin chlorination by-products

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With climate change and anthropic pressure, the occurrence of harmful cyanobacterial blooms is drastically increasing in drinking water resources. In addition, the tropical cyanotoxin cylindrospermopsin (CYL) is now emerging in temperate countries and must be considered in water treatment, in order to preserve consumer's health. Therefore, this study aims to investigate the behaviour of CYL towards chlorination (a common drinking water disinfection process) through reactants consumption, mixture composition and by-products characterization.
Due to analytical reasons, standard toxin was placed at 20µM in high purity water. Then, an aliquot of bleach solution at pH 7 was added so as to ensure a molar ratio [Cl2]/[CYL] R = 10. Mixture composition was examined through periodical acquisition of UV spectra in the range 200-400 nm and chlorine consumption was monitored according to the DPD method. In order to measure CYL transformation and to identify the related by-products, the reaction was stopped adding sodium nitrite and samples were analyzed by HPLC/MS. Based on the accurate mass resolution provided by the LTQ-Orbitrap technology and tandem mass spectrometry experiments, each by-product observed was associated with a chemical formula. Then, the cytotoxicity of chlorinated CYL was assessed on human intestinal Caco-2 cells considering mitochondrial and lysosomal activities through MTT metabolization and neutral red intake.
On the one hand, CYL monitoring reveals more than 98% toxin transformation within 2 min contact time. However, chlorine is consumed up to 20 min contact time with a rate of 5 moles per mole of CYL. In addition, thanks to Fourier transformed mass spectrometry, 3 reaction by-products are identified. The first one, called 5-chloro-cylindrospermopsin, is only an intermediate compound formed through chlorine fixation. Its fragmentation leads to the formation of cylindrospermopsic acid and another by-product called m/z 375. On the other hand, CYL chlorination significantly decreases mixture cytotoxicity since Caco-2 cells viability reaches only 40% with pure toxin but 80% with chlorinated toxin.
In conclusion, CYL quickly reacts with chlorine and forms at least 3 by-products which appear to be less toxic than the initial toxin. However, further investigation should be undertaken in order to confirm that these disinfection by-products of CYL are also formed in a human-scale treatment plant. In addition a similar approach should be applied with other drinking water treatments such as ozonation or UV irradiation.

Water Science and Water Policy: Interfacing with Community Organizations

Water Science and Water Policy: Interfacing with Community Organizations

The object of this session theme is to focus on an oft neglected aspect of water science and water policy research: essential interface with community and grassroots organizations.

Effective communication and participation can contribute to this goal. Yet with the understandable drive to ensure that good science effectively informs policy development, the community voice is seldom heard at the policy table.

Grassroots organizations, however, can muster citizen support for the collection of a wide range of credible data and ongoing environmental monitoring in an age where sharing information is becoming faster and easier. Such involvement will not only strengthen the basis for knowledgeable community input to the policy process, but also enhance the chances of widespread public acceptance of those policies.

After all, when it comes to disseminating and implementing the fruits of both science and policy, those same community groups become the front lines. At the end of the day, who better to entrust the knowledge and power required to preserve our water resources than those already well-versed, engaged and motivated, and who in their own particular environs, love them most?

This session invites presentations that illuminate one or more aspects of the theme outlined above:

- Training and mentoring local community organizations in water quality monitoring, data collection and sharing in order to standardize water data and making it more credible and communicable
- Fostering clear communication techniques in the science-policy-grassroots dialogue
- Developing useful communication materials fit for public consumption through all channels: print, media and social networking
- Structuring effective ways for policy researchers to elicit input from the community sector
- Identifying guidelines to create policy frameworks for citizen engagement

Two Muskoka Examples of Input into Public Policy

Judi Brouse, Director of Watershed Programs, Muskoka Watershed Council

Developing avenues for the average Canadian to become engaged in public policy discussions is challenging, yet fundamental to our democratic process. This talk will explore both a local and national example of public engagement.

The Muskoka Watershed Council is a collaborative effort of the District Municipality of Muskoka and the Muskoka Heritage Foundation. In Muskoka there is no Conservation Authority and an alternative model to address watershed management issues was required. The Council is made up of approximately 30 individuals from across the Muskoka watersheds and from many different areas of interest. Its mission is to Champion Watershed Health. The Council has no operating budget, yet volunteers produce well researched and pertinent position papers that are routinely considered by local municipal governments in developing policy. They also host a variety of public sessions that provide information and an opportunity for dialogue with local policy makers. This presentation will draw on examples of such initiatives in recent years.

On a national level, the Muskoka Watershed Council is working with other local agencies to host the 2010 Freshwater Summit to be held in Bracebridge on June 1 and 2, 2010. The conference will feature presentations by six distinguished speakers, among them well known environmental scientists. The speakers will help identify social, economic, and First Nations issues arising from the use of freshwater, and point out ways of assisting in the identification of possible policy innovations that might improve our ability to balance the protection of freshwater with its long term, sustainable use. Conference participants will include the general public, students, academia, and government agencies. A key product of the conference will be a policy position on the sustainable use, management and protection of freshwater. This policy position will be articulated via a public communiqué that reflects a consensus of participants' opinions. Preliminary discussions with both cabinet ministers and the G8/G20 organizing committee indicate that they will receive the final communiqué and share its insights and recommendations with their respective counterparts in cabinet and from the other countries.

Grassroots Community Engagement: Towards an Integrated Policy Approach

Natalija Milicevic, U of T graduating student in Environmental Policy Development

Science, policy knowledge, and on the ground expertise combined form an effective integrated approach to forming and implementing strategies for safe and clean water.

Implementation of policy ultimately lies at the community and grassroots level. Yet they lack a secure seat at the policy table. Basic and commonly used programs reliant upon economic incentives and information campaigns often fail to produce a significant impact upon behaviour as they do not involve public participation and subsequent commitment to the issue at hand. Knowledge campaigns may induce public acceptance of policies though not necessarily public action.

Community-based social marketing developed by Doug McKenzie-Mohr identifies commitment and social norms as key to overcoming perceived barriers to engaging in activities desired by policymakers. It is grassroots organizations operating at the community level, employing face to face interaction, who possess the ability to engage citizen support. The fluid integration of grassroots organizations with local citizens grants them access to the identifying barriers - vital policy knowledge. Most of all these groups have a vested interest in the water quality of their community and surrounding area which is demonstrated by their existing operations.

The information gathering potential, community integration, and existing activity of grassroots organizations renders them a vital asset to the policy making process.

This presentation will focus on:

- Developing useful communication materials fit for public consumption through all channels: print, media and social networking
- Structuring effective ways for policy researchers to elicit input from the community sector (methods of identifying barriers to action)
- Identifying guidelines to create policy frameworks for citizen engagement using the community-based social marketing model

New Approaches to Environmental Decision-Making: Involving Stakeholders in the Risk Analysis Process

H.C. Simpson[1, 2] and R.C. de Loë[3]

[1] Ontario Ministry of Agriculture, Food and Rural Affairs
[2] Department of Geography and Environmental Management, University of Waterloo
[3] Department of Environment and Resource Studies, University of Waterloo

There is a growing consensus in the scientific literature that expert-driven decision-making approaches on their own are not adequate for dealing with 'wicked' problems common in the environmental field. Wicked problems are characterized as having:

- Complex, uncertain, or ambiguous information;
- No clear end point;
- Competing stakeholder interests;
- 'Quasi-scientific', because more than scientific knowledge is required; and
- Risk of an adverse outcome.

New approaches are being proposed for addressing wicked problems. These bring together experts and stakeholders to share scientific and stakeholder knowledge, and incorporate societal values to create a common or 'vernacular' knowledge. These are key ingredients of new decision-making approaches that integrate risk analysis and environmental governance – something the literature terms 'risk governance'. The purpose of this paper is two-fold: (1) to describe the elements of such a broader risk governance approach, and (2) to present a case study that illustrates how such an approach can be implemented in Ontario.

Broadening Participation in Policy Analysis

Carolyn Webb, Canadian Institute for Environmental Law and Policy

With the development of the current strategic plan of the Canadian Institute for Environmental Law and Policy (CIELAP), the organization has committed to fostering the capacity of emerging young leaders and adopting a participatory engagement process in its research methodology. This is setting CIELAP on a path of engaging with community organizations and a broad range of stakeholders in its policy analysis.

Our presentation will focus on CIELAP's stakeholder engagement approach and we will review the progress made to date on our Youth Engagement in Policy Programme, which aims to engage university students in the public policy process for sustainable development.

The Canadian Institute for Environmental Law and Policy (CIELAP) is an independent, not-for-profit research and education organization. We are a registered Canadian charity and one of Canada's top environmental think tanks. CIELAP's mission is to inform legislative, policy and regulatory outcomes for sustainability at the national and provincial/territorial levels of government in Canada.

Volunteer Data Collection

David Sweetnam, Georgian Bay Forever

Water quality data collection is resource intensive and must be undertaken by practitioners trained for and experienced with the appropriate skills. Georgian Bay Forever has been using volunteers to collect samples and perform field tests in the eastern coast of Georgian Bay since 1995 with oversight from a qualified research co-ordinator. Most significantly, the data collected has led local community groups to develop their own standards of acceptable water quality and to implement grassroots programs collectively as communities. David Sweetnam is the Executive Director of Georgian Bay Forever and will give an overview of the program and its success to date.

A view from the Ontario Nonprofit Network

Lynn Eakin , Lynn Eakin and Associates

This presentation will detail innovative and creative methods of citizen engagement and grassroots participation in policy development with examples drawn from other sectors - the arts, education, and social services. Workshop participants will be encouraged to consider how similar techniques could be helpful to the world of science and policy that serves the cause of water stewardship. Lynn Eakin is the Metcalf Foundation Fellow at ONN -the Ontario Nonprofit Network. ONN is a network of networks bringing together all those working in the nonprofit sector across the various sub-sectors.

Wastewater: Investigations, Evaluations and Advances

The Reductive Degradation of the Medium Priority CMP Dye Acid Blue 129: A Potential Wastewater Treatment Approach

Salma Shirin and Vimal K. Balakrishnan

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Acid Blue 129 (AB 129) is a synthetic anthracenedione dye that is mainly used in textile industries. AB 129, as well as other dyestuffs, represents a potentially important class of organic pollutants about which little are known regarding their environmental fate. Organic compounds can undergo chemical transformations when they interact with environmental matrices; therefore, understanding these transformations is a critical aspect of assessing their environmental fate.

In the current study, Acid Blue 129 was shown to be reduced quite efficiently in the presence of zero-valent iron. Reaction products were identified using accurate masses obtained from high resolution LC-Q-ToF-MS instrumentation. At room temperature, AB 129 disappeared within 30 days whereas at elevated temperature, disappearance was found to be complete within 4hrs. Loss of the dye was attributed both to adsorption onto the Fe surface as well as through chemical transformations. The transformation appears to be a surface mediated process and proceeds via competitive reductive pathways. We found that Acid blue 129 produced 2,4,6-trimethylaniline (a potential carcinogen) as well as other aromatic reduction products in which the bioactive anthracene moiety remained intact. On the basis of our results, we conclude that not only should the parent compound be considered in when conducting environmental risk assessments, but so too should the impacts of potential degradation products.

Evaluation of model parameter sets for the prediction of activated sludge production

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Sludge production and oxygen consumption in the activated sludge process can be satisfactorily predicted with various standard kinetic and stoechiometric parameter sets regarding the heterotrophic biomass but the predicted active biomass (X_H) and endogenous residue (X_E) fractions will vary (Dold, 2007). This variation will influence the specific activity and the biodegradability of the mixed liquor, which will, notably, affect its biochemical methane potential (BMP).

The objectives of this project were to determine, at pilot scale and with real wastewaters, the active biomass (X_H) and the particulate unbiodegradable organic (X_U) fractions in the mixed liquor from a complete sludge retention experiment.

A 7 m^3 pilot membrane bioreactor (MBR; Puron, Koch Membrane Systems) was fed with primary settled wastewater from the city of Saint-Hyacinthe with 3 successive periods of feeding (1 m^3/h) and famine (no influent), for a total of 65 days of experimentation without any sludge wastage. Influent COD, TSS and VSS concentrations and mixed liquor COD, MLSS and MLVSS concentrations were measured daily from flow-paced composite samples and three times per week from grab samples, respectively. The MLSS concentration was also measured with an on-line probe (Solitax, Hach). The MBR was initially filled with the WWTP mixed liquor, operated at an SRT of 4 days.

The mixed liquor active biomass, X_H, was determined by monitoring the endogenous oxygen uptake rate by respirometry. The influent particulate unbiodegradable organic fraction (f_{UP}) was obtained by fitting the experimental MLVSS concentrations in a commercial simulator (BioWin). Both X_H and X_U were evaluated with the default simulator parameter set for the heterotrophic biomass (General ASDM model from BioWin) and the parameters proposed by Metcalf and Eddy (2003). The remaining fraction, the endogenous residue (X_E), was obtained by difference with MLVSS, X_H and X_U.

The TSS concentration rose from 2 to 12 g/L over the course of the experiment. Preliminary results showed that the influent f_{UP} was higher than the default value in the simulator (0.08). The results presented will allow to determine which parameter set is most appropriate to fit the experimental data and the impact on the predicted BMP.

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Removal of nitrate-nitrogen from wastewater will cost millions, achieve little, and may be detrimental to Lake Winnipeg

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Lake Winnipeg is the 10th largest freshwater lake in the world, has the 2nd largest watershed in Canada, and there are signs pointing to its accelerated eutrophication. Manitoba is striving to become a beacon of environmental and economic sustainability yet we see recommendations based on the precautionary principle, rather than sound engineering and scientific advice. The Manitoba Clean Environment Commission recommended that effluent quality from Winnipeg's wastewater treatment plants not exceed 15 mg N/L for total nitrogen (TN), 1 mg P/L for total phosphorus (TP), and the ratio of TN/TP be held constant at 15:1. Lake Winnipeg is approaching the sorry state that Lake Erie was in some 40 years ago. Only phosphorus control was implemented to mitigate eutrophication and today the water in Lake Erie water is clear. Neither nitrogen removal nor enforcement of effluent ammonia was implemented for protection of the aquatic environment of Lake Erie.

A sustainable approach to wastewater treatment design and operation to remove certain constituents to low levels must take into consideration the ecology of the receiving environment, the wastewater characteristics, the resources required to achieve the stipulated regulatory limit, and the measurable benefits to the upgrades would have on environment. The current debate on nitrate-nitrogen removal from City of Winnipeg wastewater is emotionally charged, with perceptions that engineers are reluctant to improve wastewater treatment to protect the environment. As such, there is an impression that the public and the regulators must stand on guard and tell engineers what to remove and how it should be done. Before perceptions become reality, technical and scientific facts should be fully analyzed to make an informed and supportable decision. Engineers are passionate about their work and would willingly design and build major capital works projects with delight, and would revel in the opportunity in operate the most modern and sophisticated treatment processes available. While it is good to dream, the reality is that engineers have signed an oath to protect the environment and the public, and are obligated to speak against unnecessary expense.

The facts in this case will be presented to illustrate how effluent permit limits for specific parameters can affect treatment plant costs and relate to water quality. There are many ways of simplifying design options and reducing costs when nitrate removal is not enforced. However, tying the N:P ratio at 15:1 means that achieving an effluent TP limit of 0.3 mg P/L (which should be implemented in due course) the effluent TN would have to 4.5 mg N/L, which approaches the limits of technology (LoT) and would likely require an external carbon for denitrification. This would be an unjustified and an egregious public expenditure. In the phosphorus-rich eutrophic Lake Winnipeg the presence of nitrates is the main factor mitigating the blue-green blooms during the summer.

Enhancing activated sludge dewaterability by applying direct current (DC) field

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Dewaterability of sludge represents either the rate of filtration or the percentage of bound water content of the sludge after dewatering (Jin et al., 2004). Sludge dewatering is considered as one of the most difficult and costly processes in treatment plants. Sludge bound water consists of four different pools: bulk water, interstitial water, vicinal water and chemically bound water. Chemically bound water is strongly attached within the floc by strong H-bonds and could be removed at 105º C (Smollen, 1990; Vesilind and Martel, 1990). Bulk water represents the part of water surround the flocs, interstitial water represents the part held by capillary forces. These two pools of water can be removed by physical means such as vacuum filtration, belt filter presses, drying beds or centrifugation. On the other hand, vicinal water represents the part that might be adsorbed or absorbed by organic solid surfaces within the microbial flocs (mainly the bound extracellular polymeric substances, EPS) through the H-bonds between the polar water molecules and the negative functional groups such as OH^- and NH_2^-. Christensen and Characklis (1990) described EPS as a hydrated matrix with 98% water content. Since the vicinal and chemically water are tightly bound to the organic surfaces and hardly removed by conventional physical means, the goal of this research is to apply direct current field to enhance the removal of microbial flocs tightly bound water through electrokinetic phenomena including elecro-osmosis.

A series of batch electro-bioreactors of 1-L volume equipped with aluminium anode and iron cathode and aerated upward at air intensity enough to maintain aerobic conditions were designed to conduct this experiment. Three mixed liquor suspended solids (MLSS) of 3000, 9000 and 14000 mg/l and five electrical exposure time modes (5'-on/5'-off, 5'-on/10'-off, 5'-0n/15'-off, 5'-on/20'-off and continuous-on) were tested at current density ranging between 5 to 35 A/m^2. Each reactor was exposed to electricity for a minimum of 70 h. Specific resistance to filtration (SRF) was measured to describe sludge dewaterability. Particle size distribution was measured to evaluate electro-biofloculation and the removal of the tightly bound water from the microbial flocs. Results showed substantial reduction of SRF ranging from a few times up to more than 200 times for almost all MLSS and all electrical exposure modes when the current density ranged between 20 to 35 A/m^2. As it was speculated, high MLSS, continuous-on and 5'-on/5'-off exposure modes showed an increase in SRF due to its negative effect on cells viability and the release of soluble microbial products (SMP) into the sludge liquor. This outstanding improvement of SRF was mainly due to the extraction of microbial flocs bound water through electro-osmosis and due to the removal of SMP and colloidal organics from the sludge liquor by electro-coagulation between flocs, SMP, and the aluminium hydroxides formed as Al^{3+} released from the anode. Flocs mean particle size was found to shrink by 1% to 32 % due to the extraction of tightly bound water over the operating period by electro-osmosis driving forces. The highest removal of bound water was achieved at current densities between 40 to 60 A/m^2, while the lowest extraction was gained at current densities between 5 to 12 A/m^2. Current densities between 20 to 40 A/m^2 exhibited 8 to 17 % reduction of flocs size. On the other hand, low current density (< 10 A/m2) was found to cause an increase of SRF mainly due to its weakness to extract the bound water. From the previous results, it is concluded that applying DC field at the proper current density and electrical exposure mode based on the MLSS concentration has a potential to substantially enhance sludge dewaterability to levels that could not be achieved in conventional treatment plants. It could be applied to submerged membrane electrokinetic system (Elektorowicz et al., 2009).

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Diverse Anammox Communities Discovered in Contaminated Groundwater Environments

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Anaerobic ammonium oxidation (anammox), discovered in 1995, is a relatively recent addition to our understanding of nitrogen cycling. Since its discovery, anammox has been estimated to be responsible for up to 67% of global nitrogen losses from marine environments, and anammox-performing organisms have been located in anaerobic environments across the globe. Anammox involves the 1:1 addition of ammonium and nitrite to generate nitrogen gas, and is mediated by a group of five known genera of microorganisms belonging to the Planctomycetes group of the Bacteria. Traditional methods of removal of ammonium from wastewater are costly and produce greenhouse gases; anammox provides a new and ecologically favorable technology for improving groundwater quality *in situ*. This collaborative effort presents the first investigation of the role of anammox in groundwater environments. Communities of anammox-performing organisms were studied at two sites in southwestern Ontario using culture independent methods including 16S rRNA gene sequencing and denaturing gradient gel electrophoresis (DGGE; a community fingerprinting technique). Several clones grouped closely with known anammox organisms, and it was found that anammox-performing communities exist and vary between contaminated groundwater sites. This project provides the first data on the existence, abundance and importance of groundwater anammox community composition, and will enable potential practical applications for the application of *in situ* techniques for remediation of groundwater and the treatment of nitrogen-rich wastewater

MAPPING AND CFD ANALYSIS OF MULTI-LAMP PHOTOREACTORS FOR AQUEOUS DEGRADATION OF METRONIDAZOLE

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ABSTRACT

Photochemical reactors have been widely used in water and wastewater treatment during recent decades. Increasing the number of UV lamp inside the photoreactors enhances the local volumetric rate of energy absorption and results in higher degradation rate of organic compounds. The number of UV lamps and their locations influence the fluid flow characteristics and the degradation efficiency. Understanding the fluid flow and the synergetic effects caused by UV lamps is helpful to get maximum advantages of irradiation with minimum electrical energy consumption. In this study, different locations of four lamps are analyzed to compare their effectiveness. Computational fluid dynamics (CFD) is used to investigate fluid flow for different configurations. k-ε turbulent model is used for CFD analysis to find velocity profile, turbulent kinetic energy, turbulent dissipation rate, turbulent viscosity, and vorticity. Metronidazole is selected as a model compound to investigate its degradation for different configurations.

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Sensitivity analysis for trash and grit removal from activated sludge by microscreening and hydrocycloning to reduce sludge production

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Sludge treatment and disposal costs represent up to 50% of the operating costs for biological wastewater treatment plants (WWTPs). It is well known that increasing solids retention time (SRT) leads to decreased sludge production. Although operating at higher SRTs would enable WWTPs to decrease their sludge production, it would also lead to changes in the relative proportions of mixed liquor constituents. Indeed, as SRT increases, the fraction of biomass in sludge is diminished, but there are increases in the fractions of endogenous cell debris, influent unbiodegradable organic particulate matter (including trash), and influent unbiodegradable inorganic particulate matter (including grit). Trash and grit accumulate in the sludge and can typically represent 25-60% of the solids content of activated sludge yet they do not participate in wastewater treatment.
Selective removal of trash by microscreening and grit by hydrocycloning from activated sludge was quantified at laboratory scale on sludges from eight WWTPs in the Greater Montreal area, with industrial loadings ranging from 0 to 99% and various combinations of pre- and primary treatments. Microscreening activated sludge resulted in a removal of 33 mg VSS per g total suspended solids (TSS) for WWTPs without a primary clarifier and of 4.7 mg VSS per g TSS for WWTPs with a primary clarifier. Hydrocycloning activated sludge was shown to concentrate the TSS in the underflow by 40% and the grit (extracellular fixed suspended solids) by 80%.
A latin hypercube experimental design generated by JMP was used to perform a sensitivity analysis for the effects of SRT (5 to 50 days), influent wastewater unbiodegradable organic (fup = 0.02 to 0.50) and inorganic matter content (influent fixed to TSS fraction, iFT 5 to 50%) and the proportion of return activated sludge (RAS) microscreened (0 to 100%) or hydrocycloned (0 to 100%) on sludge production. Simulations were carried out using the wastewater treatment plant simulator, Biowin.

Simulation results were analysed by Statistica and showed that sludge production could be reduced by increasing SRT and selectively removing trash and grit from activated sludge.

Comprehensive Wastewater Treatment Plant and Sludge Pretreatment Model

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Organic matter hydrolysis (20-60% particulate matter solubilisation) by physical, thermal, chemical, and thermochemical pretreatments (SPTs) prior to anaerobic digestion (AD) has been shown to improve biogas production (30-50%) and reduce solids (20-60%). A thorough literature review of over 150 studies has outlined that the financial feasibility of SPT incorporation in conventional wastewater treatment plants (WWTPs) has not been addressed. A comprehensive model was thus created using Microsoft Excel and its Visual Basic Assistant to evaluate SPT permutations for WWTPs. Model validity was assessed and recognized by comparison to Plan-It STOAT (WWTP design software package). The SPTs (e.g., ultrasound, microwave, alkaline) that make up the four above-mentioned categories were evaluated for energy and financial demands. Well-established energy equations and wastewater characteristics (low to high) were used. Low to high raw feed flows were set at 240 and 750×10^3 m^3/d for a 10^6 design population. Daily costs are output by the model and "dynamic" yearly costs were determined from low to high flow regimes and varied treatment conditions that result in low or high costs. Incorporation scenarios were evaluated for low to high SPT energy demands resulting in identical hydrolysis levels. Mesophilic and thermophilic AD were also compared. All positive results (i.e., feasible incorporation) were highly dependent of heat recoveries from SPT energy input, biogas improvements, and low SPT energy demands for specified hydrolysis levels. Negative results (i.e., financially undesirable incorporation) for all SPTs were found in the over 320 computed model permutations. Positive and negative results outline the potentially feasibility of SPT incorporation as well as the significant importance of this comprehensive model for site-specific SPT incorporation assessments.

Environmental Modeling

Elucidation of ecosystem attributes using Ecopath with Ecosim (EwE): Application to an Oligotrophic lake in Hokkaido, Japan.

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The fishing practices in the oligotrophic Lake Toya, Hokkaido, Japan, have profound implications in the ecosystem sustainability. In particular, the status of the sockeye salmon (*Oncorhynchus nerka*) population has become a serious concern among the lake managers and policy makers during the last decades. Whilst the decline of the sockeye salmon population has been well documented in Lake Toya, there is considerable uncertainty with regards to the impact on the broader system dynamics. In this study, our objective is to address this knowledge gap by undertaking a synthesis of the Lake Toya food web using the mass-balance modeling software Ecopath with Ecosim (*EwE*). Our primary research question is to examine the repercussions of the declining sockeye salmon population on the trophic dynamics of the lake. Namely, we assess if there are any competing species that might have benefited from the decrease of sockeye salmon standing biomass and to what extent do these changes cascade through the Lake Toya food web? Our analysis pinpoints the critical role of the Japanese smelt in the system, which demonstrates a wide range of effects on several functional groups at both higher and lower trophic levels in Lake Toya. In particular, being a substantial portion of the masu and adult sockeye salmon diets, the Japanese smelt has a positive impact on the top predators of the system. Amphipods, insects, and shrimp strongly benefit from the autochthonous and allochthonous organic matter in the system, while the tight coupling between phytoplankton and zooplankton seems to be particularly critical for the integrity of the Lake Toya food web. Whereas the values of the different ecosystem attributes (e.g., primary production/biomass, biomass/total throughput, System Omnivory Index, amount of recycled throughput, Finn's cycling index) provide evidence that Lake Toya is an immature system, we note that the internal redundancy and the system overhead estimates suggest that the lake possesses substantial reserves to overcome external perturbations. We also examined the effects of a variety of fishing policies on the biomass of masu salmon and adult sockeye salmon, which verify the belief that the adult sockeye population is quite fragile with high likelihood to collapse. Our analysis also predicts that sockeye will not rebound unless the fishing pressure exerted is substantially reduced (> 50% of the reference levels used). Masu salmon seems to benefit under all the scenarios examined indicating that the intensity of the current fishing activities is significantly lower than its biomass accumulation rate in the system.
Keywords: Food web modeling, Ecopath model, Fisheries, Lake management, Ecosystem attributes, Network analysis, Lake Toya, Sockeye salmon.

Use of Models in Watershed Management

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Hydrologic and hydraulic models are now widely used in watershed management. Models can us help understand the system dynamics of watersheds and do routine computations of hydrologic phenomena. Although models are seen primarily as a technical tool, they are now being increasingly used to support policy formulation and dispute resolution. Drawing on the experience of the recent use of models at Rideau Valley Conservation Authority, the current use and future potential of numerical models in watershed management are elucidated. It was found that models can be used to analyze problems in an objective way and to communicate technical information to policy makers and general public.

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Integration of mathematical modeling and Bayesian inference for setting water quality criteria in Hamilton Harbour, Ontario, Canada.

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Abstract: The credibility of the scientific methodology of mathematical models and their adequacy to form the basis of public policy decisions has frequently been challenged. We argue that the development of novel methods for rigorously assessing the uncertainty underlying model predictions should be a top priority of the modeling community. Striving for novel uncertainty analysis tools, we believe that the Bayesian calibration of process-based models is a methodological advancement that warrants consideration in aquatic ecosystem research. This modeling framework combines the advantageous features of both mechanistic and statistical approaches, i.e., mechanistic understanding that remains within the bounds of data-based parameter estimation. Other advantages of the Bayesian approach is the ability to sequentially update beliefs as new knowledge is available, and the consistency with the scientific process of progressive learning and the policy practice of adaptive management. In this study, the Bayesian calibration framework is used to guide the water quality criteria setting process in Hamilton Harbour; a eutrophic system in Ontario, Canada. First, we present the results of the Bayesian calibration exercise and examine the ability of the model to sufficiently reproduce the average observed patterns along with the major cause-effect relationships underlying the Harbour water quality conditions. We then address the following critical questions regarding the future response of the system: How possible is it to meet the objective of delisting the study system as an Area of Concern, if the nutrient loading reductions proposed by the Hamilton Harbour Remedial Action Plan are actually implemented? What additional remedial actions are needed to increase the likelihood of meeting the water quality targets? In this regard, the present modeling study undertakes an estimation of the critical nutrient loads in the Harbour based on acceptable exceedance frequencies and confidence of compliance levels with different water quality criteria (e.g., chlorophyll a, total phosphorus). Our analysis suggests that the water quality goals for *TP* (17 $\mu g\ L^{-1}$) and chlorophyll *a* concentrations (5-10 $\mu g\ L^{-1}$) will likely be met, if the recommendation for phosphorus loading at the level of 142 kg day^{-1} is achieved. We also provide evidence that the anticipated structural shifts of the zooplankton community will determine the restoration rate of the Harbour. Finally, we pinpoint two critical aspects of the system dynamics that invite further investigation and will likely modulate the stability of the new trophic state, i.e., the coupling between the benthic and pelagic habitat and the relative importance of the allochthonous organic matter in sustaining the secondary production in the system.

Keywords: Phosphorus loading, Eutrophication modeling, Risk assessment, Hamilton Harbour, Ecosystem restoration, Top-down control, Benthic-pelagic coupling.

Sediment and Nutrient Loading from Big Creek Watershed, Ontario

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Nutrient and sediment deposition into receiving surface water bodies is continued to be of major public health concern due to eutrophication and Hypoxia. The present study forms a small part of the Big Creek watershed plan development being carried out by various stakeholders including the farmers, Essex Region Conservatory Authority, Town of Amherstburg, the Province of Ontario, Environment Canada, etc. This plan aims to identify and assess the natural resources in the Big Creek and develop appropriate strategies to protect and/or manage these natural resources under present condition and as land use or other changes that may occur over time.

The objective of the present study is to model the sediment and nutrient loading from the Big Creek watershed in Essex Region using Annualised AGricultural Non-Point Source (AnnAGNPS) pollution model. The model is used to evaluate the response of the Big Creek watershed to various agricultural practises implemented at the outlet point, in this case, Lake Erie. The study presents the results of the annual and seasonal variations in the sediment loadings. These outputs will be used to identify both structural and non-structural BMPs along the source areas and reduce the pollutants.

Numerical Modeling of Hydrodynamics and Tracer Dispersion in Lake Winnipeg

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A three-dimensional hydrodynamic modeling system (ELCOM) is used to study the circulation and thermal structure in Lake Winnipeg. To assess the model performance, we simulate the circulation and temperature distribution of the lake in 2007 and compare the model results with the observations made in the lake. The model showed considerable skill in reproducing the thermal structure, surface currents and water levels. The modeled currents are used to examine the transport and dispersion of passive tracers, local flushing time, and retention and hydrodynamic connectivity of passive particles in the lake. Simulations using passive tracers qualitatively agreed with the measurements of deuterium in Lake Winnipeg during the study period.

Calibrated and Physically Distributed HSPF Model for Rural and Urban Watersheds

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EPA HSPF software is basically a lumped hydrologic model. An innovative techniquehas been applied to develop a physically distributed and calibrated hydrologic modelusing the software for the NVCA and SSEA watersheds. Each of the watersheds isdiscretized into subwatershed, catchment and subcatchment. The model uses landuse/cover, Hydrologic Soil Group (HSG) and small size climate zone to representphysical and spatial distribution of hydrologicresponses. Each of the subcatchment isfurther discretized into 46 Unit Response Functions (URFs), which are developed from combinations of land use/cover and HSG. The URFs represent both rural and urban land use/cover in Ontario. The rural URFs represent agricultural crop/pasture, forest, hummocky, open place, water body and wetland land use/cover. The urban URFs include Low/Medium/High Density Residential, Industrial, Commercial, Education/other Institution, Park/Open Place, Highways and Roads land uses. The model can simulate several types of urban runoff such as sloped roof, flat roof, driveway, parking and storm
sewer. To capture spatial distribution of climate data, the watersheds are divided into 64 climate zones. It uses over 50 climate stations' data to estimate climate data at centroid of each climate zone. The PEST auto-calibration (Doherty, 2008) technique is applied to calibrate HSPF

parameters. A total of 375 parameters were calibrated using PEST and simulated streamflows of 17 WSC gauge stations. A number of FORTRAN codes are created to do pre and post model processing, which includes filling missing climate data, estimating climate data at climate zone centroid, creating FTABLE from stream cross-section data, importing URF data (GIS) to the model and exporting model output to ArcGIS. These codes have made the pre and post model processing much simpler and quicker. As each of the URFs is effectively a "sub-model". The URFs represent both urban and rural land use/cover of any small size, and are physically distributed within a watershed or subwatershed. The model has small size climate zones to capture spatial distribution of climate data. At the same time, the auto-calibration of the HSPF parameters has provided excellent results, where the simulated streamflows match very well with the observed streamflows. The HSPF model estimates long-term annual average and monthly total groundwater recharge of the NVCA and SSEA watersheds for the Tier 2 Water Budget analysis. The estimated recharge was applied as input to FEFLOW model of the watersheds for the Tier 2 Water Budget analysis.

Occurrence, Fate and Relevance of Contaminants in Aquatic Systems

APPLICATION OF MULTIVARIATE STATISTICAL TOOLS IN BIOLOGICAL EARLY-WARNING SYSTEMS (BEWS) FOR THE DETECTION AND IDENTIFICATION OF SPECIFIC CLASSES OF CONTAMINANTS

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Current freshwater quality monitoring methods are inadequate due to their reliance on expensive and timely off-line laboratory analyses. A more economical and faster approach to water quality monitoring is the *in-situ* biological early-warning system (BEWS). BEWS is an emerging water-surveillance technology which continuously measures the behavioural parameters of an organism in a monitoring chamber. Many aquatic organisms are sensitive to changes in water quality, and thus their short-term response characteristics can be modelled and used as biosensors. Some publications have documented the effects of several contaminants on the behavioural parameters of selected aquatic organisms: the macrophyte *Lemna minor*, the green algae *Pseudokirchneriella subcapitata*, the single-celled protist *Euglena gracilis*, the freshwater bivalve *Anodonta grandis*, the invertebrate crustacean *Daphnia magna*, the freshwater amphipod *Hyalella azteca*, and the oligochaete worm *Lumbriculus variegatus*. Published results indicated that each organism exhibited a different set of responses to each contaminant, and each class of contaminant elicits a different set of responses from each organism. By modelling the response data according to species and class of contaminants, this study aims to develop a holistic system that is capable of both detecting and identifying the types of stressors. Multivariate statistical tools such as principal component analysis will be employed to reduce the number of dimensions and reveal causal relationships among variables. The detailed methodologies for modelling and interim results of this study are presented in this paper.

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Cloning of *cry 1* and cry 4 genes from native *<u>Bacillus thuringiensis</u>* isolated from the Western Ghats of Kerala

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The continous use of synthetic pesticides has led to serious problems like environmental degradation and increased resistance of insect pests, has created a renewed interest for the development of biological alternatives to chemical pesticides. *Bacillus thuringiensis*, the gram positive, spore forming bacterium produces larvicidal proteins which possess insecticidal activity against insects belonging to the orders Lepidoptera, Diptera, Coleoptera and many others. Bacillus thuringiensis is considered as one of the most versatile microbial insecticide that had been used for the last half century. The strict specificity of bacterial strains to certain orders of insects, makes it the most environmental friendly alternative to about 5 percentage of 2 million tons of chemical insecticide.

Intensive screening programmes are going on worldwide to isolate new bacterial strains with increased level of insecticidal activity against a broader spectrum of insect pests. In this research work an attempt has been made to isolate Bacillus thuringiensis from the Western Ghats of Kerala in India. The Western Ghats of India is one among the eighteen hotspots of biodiversity in the world and is expected to harbor novel isolates of Bacillus thruringiensis. Very few attempts have been made by scientists to explore the microbial diversity of Western Ghats. It is expected that great biodiversity exists among bacterial strains in this area, due to co-evolution along with insects or by conjugal transfer of plasmids to other strains and hence attempts are needed to explore novel genes. In the present study, eleven Bacillus thuringiensis strains were isolated from the soils of Western Ghat region of Kerala, India, which is potentially undisturbed ecological niche.

Morphology of the isolates on Luria Bertani Agar medium revealed similarity with the standard strain Bacillus thuringiensis HD1. Staining with Coomassie brilliant blue revealed the presence of dark blue crystal proteins having spherical, irregular, bipyramidal and triangular shapes. Biochemical characterization of the isolates showed variable response to hydrolysis of urea, starch and esculin. The insecticidal activity of the native isolates against Pumpkin caterpillar (Diaphania indica), a major lepidopteran pest of cucurbitaceous vegetables, was assessed by diet incorporation method. Except for one isolate, all other native isolates were able to produce 90 percent mortality on eighth day compared to 100 percent mortality caused by standard strain. The native isolates were classified as efficient ones, though the entomotoxic potential was slightly less than the standard strain.

Profiling of *cry 1* and cry 4 genes of the bacterial isolates was done using universal *cry 1* and *cry 4* primer. Amplification with universal *cry 1* gene primer was obtained for eight isolates, producing a fragment of 250 bp size. Amplification for *cry 4* gene, specific to diptera was obtained for two isolates, with an amplicon size of 531 bp. PCR with *cry 1A* primer, designed during the study, yielded amplification for two isolates with an amplicon size of 554 bp. The amplified fragments were cloned and sequenced. Theoretical analysis of sequence showed 100 per cent identity with *cry 1* and *cry 4* genes. In order to amplify the variable region of *cry 1* gene, PCR was carried out using *cry 1* primer designed by Juarez-Perez *et al*. (1997) for which amplification was obtained for two isolates, with an amplicon size of 1500 bp. Presence of cry 4 gene, specific to dipteran larvae, in the native isolates holds the great potential for further investigation of insecticidal activity against dipteran insects. Cloning of novel and full length cry genes, which can be expressed in transgenic crops is a potential strategy to combat resistance development in insect populations.

Deteriorating Water Quality and Physical Conditions of Coastal Beaches of the Great Lakes – Is Groundwater to Blame?

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Over the past decade, public beachgoers and local residents have observed deteriorating beaches along the shores of the Great Lakes. Several beach problems continue to persist, including: high levels of *Escherichia coli* (*E. coli*), invasive hydrophytic vegetation (e.g., *Phragmites*, sedges, rushes), loss of sand, and wet conditions. As a result, a concerned public is demanding actions and answers on why their beaches are deteriorating. This study was conducted to address public concerns, focusing on the problem of why some beaches are always wet (and exhibit a variety of problems) and why other beaches are always dry (and generally do not exhibit any problems). Specifically, this study investigated the physical and groundwater conditions present at these beaches that contribute to their deterioration. Combinations of field and laboratory methods were used to quantify groundwater conditions and the physical properties of beach sand at several beaches along the shores of southern Georgian Bay. Analyses of grain size distributions, moisture contents, water table depths, and ground surface elevations, along with observations of vegetation provided a clear picture of the physical and hydrogeological differences between beaches that are wet and beaches that are dry. Results indicate that dry beaches tend to have relatively coarser-grained sand, have low moisture contents, and a deep water table. Wet beaches are tend to have relatively finer-grained sand, high moisture contents, and a shallow water table. Also, hydrophytes (e.g., *Phragmites*, sedges, rushes) were observed only at wet beaches and beach grass was observed only at dry beaches. Results suggest that the presence of wet and dry beaches is controlled by their physical sand properties and water table depth, in turn controlling groundwater conditions. Changing some of these conditions, either naturally or by human activities could convert dry beaches to wet beaches, and vice versa. Furthermore, wet beaches may provide conditions more conducive to the infiltration and transport of surface contaminants (e.g., *E. coli*) to the water table, and also provide suitable hydrologic conditions for the growth and survival of invasive hydrophytic vegetation.

Identification of nonpoint sources of fecal water pollution by TaqMan® real-time PCR assays using *Bacteroides* 16S rRNA genetic markers

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The PCR-based analysis of *Bacteroides* 16S rRNA genes has recently emerged as a promising tool to identify the nonpoint sources of fecal water pollution. In this study, three novel TaqMan® real-time PCR assays (BacGeneral, BacHuman, and BacBovine) were developed and evaluated for their ability to quantitatively detect the total, human-specific, and bovine-specific *Bacteroides* 16S rRNA gene markers. The PCR threshold cycle exhibited a strong inverse linear relationship with the logarithm of the target gene copy number ($r^2 > 0.99$), indicating that these assays can be reliably applied to quantify the genetic markers. The detection sensitivity was determined to be 6.5 copies of 16S rRNA gene, or approximately 1 cell per PCR. The assays were also tested with 70 reference fecal samples from various sources (human, cattle, pig, deer, dog, cat, goose, gull, horse, raccoon), and the result showed a high diagnostic sensitivity for all three assays (i.e. 100 % true positive identification of the target markers) without any false-negative reactions. The BacHuman and BacBovine assays exhibited diagnostic specificities lower than 100% due to their cross-reactions with samples from non-target animals in limited cases. However, the false-positive reaction signals were lower than the true positive signals by two orders of magnitude, and therefore these cross-reactions hardly affected the quantitative identification of host-specific markers. When MST capability was tested at two freshwater streams of which water quality is known to be influenced by different fecal sources (human or bovine), the assays accurately identified the fecal pollution source for each stream. The current method is expected to reliably determine human and bovine fecal pollution sources in the environment.

The Toxicity of Harmony Landfill Leachate to Green Hydra

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Harmony Landfill is a former industrial waste disposal site located immediately adjacent to Harmony Creek in the city of Oshawa, Ontario, Canada. During its operational period from 1957 to 1980, approximately 1 million tonnes of waste, primarily from automotive manufacturing, were deposited at the 9-acre landfill site. Although ground and surface water monitoring programs were initiated during active waste disposal in the 1970s, the current environmental impact of the landfill on local water sources is unknown. Recent water chemistry analyses have revealed elevated levels of some metals in surface water samples taken adjacent to the site. In order to determine the potential impact of Harmony Landfill leachate on aquatic organisms in nearby surface waters, laboratory toxicity tests were conducted on the model freshwater invertebrate *Hydra viridissima* (Green Hydra). Hydra were pulse-exposed to varying concentrations (0%, 3.2%, 10%, 32%, 100%) of monthly field-collected surface water samples diluted with laboratory water. Population reproduction was at 25° C was recorded daily for 7-8 days. Current findings indicate that any leachate flowing from Harmony Landfill has a low potential to negatively affect aquatic invertebrate populations inhabiting adjacent surface waters including Harmony Creek.

Potential Contribution of Micro- and Mesofauna to Phosphorus Release from Fish Farm Sludge

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Microfauna (protozoans and small metazoans) and mesofauna (tubificids worms and chironomids larvae) living at the water/sludge interface directly influence phosphorus dynamics. This study reports experimental results from an earth pond system used to culture Brook trout, *Salvelinus fontinalis*. Samples for biological and physical chemical analyses were taken from water, sludge accumulating at the bottom of the pond through the production season (BS) and sludge accumulating in a sludge collecting device (CS) (which is considered as "young" sludge since it was extracted every week). The pond was monitored during four months and abundances of organisms recorded where employed to calculated their potential contribution to phosphorus mobilization of fish farm sludge by using their phosphorus release capacity described in literature. Flagellates were the most abundant group in water and sludge (either BS or CS) and they represented the group with the highest biomass in BS (390 µg/g sludge). However, the most important biological group in terms of biomass for the CS was the chironomid larvaes ($4.4 \cdot 10^5$ µg/g sludge). Flagellates and chironomid larvaes showed the highest potential capacity for P release (3.23 and 515 mg P kg $sludge^{-1}$ d^{-1}, respectively), which implies that they might be able to mobilize the whole phosphorus content of BS (290 mg P/kg sludge) within less than one day and three months to the chironomids and flagellates, respectively. Results also evidence that the presence of microfauna and mesofauna communities is highly dependent on the type of sludge considered. Accordingly, CS (one-week-old sludge) has no presence of chironomids larvaes, small metazoan or tubificid worms, and the abundances of ciliates and flagellates are much lower when compared to BS. Therefore, the periodical removal of sludge generated in a fish farm should contribute to reduce the phosphorus released by micro and mesofauna communities.

DESIGN AND VALIDATION OF OLIGONUCLEOTIDE PRIMERS FOR THE DEVELOPMENT OF A STANDARDIZED QPCR PROTOCOL TO DETECT WATERBORNE BACTERIAL PATHOGENS

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Gastroenteritis caused by waterborne pathogens affects roughly 2 million individuals annually (WHO, 2003). Traditionally, indicator organisms are used as the main evaluator of threats to water quality, however, correlation between indicators and pathogens is becoming less prevalent since they do not always co-exist. As such, assays based on the polymerase chain reaction (PCR) have been proposed as a platform for the development of novel and standardized detection systems. The objective of this study was to examine the feasibility of using quantitative real time PCR (qPCR) as a standardized technique to detect *E. coli* O157:H7, *Campylobacter jejuni*, *Salmonella typhimurium*, *Shigella flexneri* and *Pseudomonas aeruginosa* in Ontario source water. A robust set of oligonucleotide primers were designed by using the LightCycler Probe Design2 software (Roche Diagnostics, Laval, Quebec) to target virulence-associated genes; having both high specificity and increased sensitivities for low pathogen loads, as determined experimentally. Primers were tested with pure culture and both naturally and artificially contaminated Lake Ontario water samples to evaluate their effectiveness. The detection limits obtained indicate that 53, 215, 420, 30 and 12 genome equivalents for each of the previously mentioned pathogens can be detected with the newly designed primer sets. Future testing will involve a comparison of the primer sets in real-time PCR to traditional coliform counts using environmental samples. It is expected that the proposed detection system will allow rapid, sensitive, and quantitative pathogen detection within a matter of hours.

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Assessment of the Environmental Release and Eco-toxicological Relevance of Illicit Drugs

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The detection of illicit drugs in environmental matrices may be a cause for concern, both from the perspective of their potential environmental impacts and the fact that their presence in detectable concentrations would be an indicator of significant drug use. The primary objective behind recent studies on this subject has been to use measured concentrations of selected illicit drugs in the environment as a means of back calculating the epidemiological prevalence of these drugs and patterns of consumption. Typically, such back calculations hinge on the use of solitary excretions estimates from either a single study or grey literature. Therefore, the need exists to conduct a meta-analysis of a number of suitable excretion studies to evaluate excretions profiles of the various drugs which will not only provide mean excretions values but also indicate the expected variations (e.g., confidence intervals). After conducting such a study on a variety of illicit drugs including amphetamine, cocaine, heroin, methamphetamine, 3,4-methylenedioxymethamphetamine (MDMA) and tetrahydrocannabinol (THC), the results obtained clearly indicate that certain extrapolation factors currently being used in literature to enumerate epidemiological prevalence are erroneous. Furthermore, the analysis also highlights the need for more thorough metabolic profiling studies for compounds such as MDMA and THC before their measured environmental concentrations can be used for purposes of back calculating epidemiological prevalence. An additional goal of the current investigation was to assess, albeit at a screening level, the potential eco-toxicological relevance of such contaminants and their metabolites. The results obtained suggest that, based on the data currently available, such contaminants and their metabolites are unlikely to pose an eco-toxicological risk. However, a few key eco-toxicological gaps must be addressed before this can be stated with a certainty.

Gene Expression Changes in Rainbow Trout (*Oncorhynchus mykiss*) Exposed to Randle Reef Sediment

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Hamilton Harbour was identified as an Area of Concern (AOC) in 1985 by the International Joint Commission. As a result of that designation there is a Remedial Action Plan (RAP) to restore the harbour's beneficial uses. The sediment in Randle Reef is highly contaminated with Polycyclic Aromatic Hydrocarbons (PAHs) and heavy metals. We are developing a set of molecular tools for use in fish to track the efficacy and progress of the remediation process for Randle Reef. We used the Fluorescent RNA Arbitrarily Primed Polymerase Chain Reaction technique (FRAP-PCR) to identify genes that were differentially expressed in rainbow trout after their exposure to Randle Reef sediment in the laboratory(2-,10-, & 21-d). FRAP-PCR revealed over 70 identifiable gene transcripts from livers of the exposed fish. Preliminary analysis also yielded 11 genes from brain and 15 from blood samples from the same fish. The parent genes of those differentially expressed transcripts were identified by BLAST analysis of the cloned and sequenced cDNA. Gene Ontology analysis of the genes identified by FRAP-PCR indicated that sediment exposure altered the expression of genes in the following categories: cell adhesion, cell morphogenesis, DNA synthesis, immune responses, metabolism, proteolysis, reproduction, cell respiration, response to stimulus, cell transport. Quantitative polymerase chain reaction (qPCR) data showed that the PAH inducible gene CYP1A was significantly ($P<0.05$) induced on exposure to Randle Reef sediment. Unexpectedly, we also observed significant induction of vitellogenin (Vtg) mRNA ($P<0.05$) which was consistent with up-regulation of Vtg protein as measured by ELISA ($P<0.05$) in the sediment exposed rainbow trout.