

ORAL PRESENTATIONS

Monday, February 10th, 2003

Main Mall		
07:45	<ul style="list-style-type: none"> • Registration • Poster Installation 	
Plenary Session: Auditorium		
08:30	Welcome to the National Water Research Institute DR. JOHN H. CAREY, Director General, National Water Research Institute	
08:35	Opening Remarks: MIKE N. LYWOOD, President, Canadian Association on Water Quality	
08:45	Plenary: DR. JOHN LAWRENCE, Director, Aquatic Ecosystem Management Research Branch, National Water Research Institute “The Scope of the Challenge: Threats to Water Quality”	
Room	Session 1 – Auditorium	Session 2 – North/South Seminar Room
Theme	SURFACE WATER: ENVIRONMENTAL EFFECTS Chair: JOANNE L. PARROTT Research Scientist National Water Research Institute	GROUNDWATER: QUALITY, QUANTITY AND REMEDIATION Chair: NATHALIE ROSS Research Scientist National Water Research Institute
09:30	Overview of Fish and Wildlife Health Effects and Exposure Studies in Canadian AOCs <u>S.BROWN</u> , J. STRUGER AND G. FOX	Regional Scale Assessment of Groundwater Conditions Within the Great Lakes Basin A.R. PIGGOTT
09:55	Assessment of the Estrogenic Potency of Effluents from Petrochemical Facilities and a Petroleum Refinery in Ontario J. SHERRY, T. TREPANIER, C. TINSON, T. MORAN, T. KIERSTEAD AND S. MUNRO	City of Guelph Response to Ontario Regulation 459/00 – Drinking Water Protection Regulation P. BUSATTO, D. STENDAHL, <u>D. MUTTI</u> , E. EDWARDS AND C. KORN
10:20	National Assessment of Pulp and Paper Mill Environmental Effects Monitoring: Presence of Large-Scale Response Patterns R.B. LOWELL, J.M. CULP, L.C. GRAPENTINE, <u>M.E. MCMASTER</u> , K.R. MUNKITTRICK AND S.C. RIBEY	Establishing GUDI Status and Quantifying the Level of Natural In situ Filtration: Microscopic Particulate Analysis (MPA) Used in Conjunction with Hydrogeology Principles by the Greater Cincinnati Water Works <u>J.L. CLANCY</u> AND W.D. GOLLNITZ
10:45 Health Break – Main Mall		
11:00	Physiological and Biochemical Responses of Small Fish Exposed to Athabasca Oil Sands Sediment <u>G.R. TETREAULT</u> , M.E. MCMASTER, D.G. DIXON AND J.L. PARROTT	Contamination of Groundwater by DDT at Point Pelee National Park, and Potential Risks to Ecosystem and Human Health <u>R. MILLS</u> ,* A. CROWE AND J.E. SMITH
11:25	Changes in Growth, Secondary Sex Characteristics and Reproduction of Fathead Minnows Exposed for a Lifecycle to Bleached Sulphite Mill Effluent <u>J.L. PARROTT</u> , C.S. WOOD, P. BOUTOT, B. BLUNT, M. BAKER AND S. DUNN	Removal of Arsenic from Contaminated Water Using Coagulation Enhanced Microfiltration <u>K. VOLCHEK</u> , D. VELICOGNA, A. DUMOUCHEL, W.P. WONG AND C.E. BROWN
11:50	TerraQSAR™ - FHM, a Probabilistic Neural Network-Based PC Program to Estimate the Acute Toxicity of Chemicals to Fish K.L.E. KAISER	Ralgreen Restoration Project. A Brownfield Cleanup in a Residential Neighbourhood <u>R. FEDY</u> , <u>P. GRAY</u> , R. BARNES AND J. WITMER
12:15 Lunch – Main Mall		

Room	Session 3 – Auditorium	Session 4 – North/South Seminar Room
Theme	SURFACE WATER: MODELLING AND MICROBES Chair: CHRIS MARVIN Research Scientist National Water Research Institute	SURFACE WATER: NUISANCE ALGAE Chair: BIN ZHU Research Scientist National Water Research Institute
13:15	Techniques and Protocol for Watershed-Level Calibration of an AnnAGNPS Simulation <u>G. PARKER</u> , * R.L. DROSTE AND K.J. KENNEDY	<i>Cladophora</i> , an Alga Fouling Great Lakes Shorelines T. HOWELL
13:40	Pollution Studies on Surface Water of the Southwest Coastal Plain of the Caspian Sea Area: A Case Study of the Syahrood Watershed in Central Gilan, North of Iran A.H. CHARKHABI	<i>Cladophora</i> , an Alga Fouling Great Lakes Shorelines (continued)
14:05	Lake Sediment Structure and Evolution (LSSE) Research: Towards Predictive Reaction Transport Models <u>D.G. RANCOURT</u> , I. L'HEUREUX, S. KATSEV, B. GEORGE, C. McDONALD AND K. TELMER	Are Dreissenids Responsible for the Recent Increase of Potentially Toxic Cyanobacterial Species in Lake Erie? <u>A. GHADOUANI</u> AND R.E.H. SMITH
14:30	Health Break – Main Mall	
14:45	Estimation of Atrazine Loss through the Surface Runoff in the Lake Erie Basin <u>B. CHEN</u> , * Y.F. LI, G.H. HUANG, B.Y. ZHANG AND S.M. WU	An Update on Analysis of Algal Toxins from Algae, Fish and Duck Species In and Around Lake Winnipeg C.R. HERBERT, <u>H.J. KLING</u> AND M.P. STANTON
15:10	Toxicity and Estrogenic Activity Reduction of Aqueous Solutions of Alkylphenols Using Peroxidase Enzyme M. WAGNER AND <u>J.A. NICELL</u>	Natural Transformation of <i>Pseudomonas</i> spp. Isolated from Water Samples B. ZHU
15:35	The Microbial Degradation of Common Plasticizers <u>O.HORN</u> , * S. NALLI, D.G. COOPER AND J.A. NICELL	Method Development for Microcystins in Environmental Samples S.W.D. JENKINS, P.W. CROZIER AND <u>V.Y. TAGUCHI</u>
16:00	Photolysis of Naphthenic Acids in Natural Waters <u>D.W. McMARTIN</u> , * J.V. HEADLEY, D.A. FRIESEN, K.M. PERU AND J.A. GILLIES	
16:30	Poster Social/Pre-meeting Break – Main Mall	
17:00	CAWQ Annual General Meeting – Auditorium	

* Competing for the Philip H. Jones Award.

Tuesday, February 11th, 2003

Main Mall		
07:30	• Registration	
Room	Session 1 – Auditorium	Session 2 – North/South Seminar Room
Theme	WASTEWATER TREATMENT Chair: MANO MANOHARAN Senior Specialist, Wastewater Standards Development Branch Ontario Ministry of the Environment	WET-WEATHER FLOW POLLUTION CONTROL Chair: JIRI MARSALEK Project Chief National Water Research Institute
08:00	Extracellular ATP: A New Early Warning Tool to Detect Stress in Activated Sludge Microorganisms <u>J. CAIRNS, P.A. WHALEN AND P.J. WHALEN</u>	Stormwater Control in a Flow Balancing and Wetland Treatment Facility <u>D.W. AVERILL, T. VAN SETTERS, S. ORMONDE AND L. ARISHENKOFF</u>
08:25	Study on Cell Agglomeration in Mixed Acidogenic and Mixed Methanogenic Cultures at Different Loading and Mixing Conditions <u>M. VERMA, T.R. SREEKRISHNAN AND R.D. TYAGI</u>	Pilot-Scale Investigations of High-Rate Stormwater Treatment <u>Q. ROCHFORT, P. CHESSIE, M. YANG, S. ORMONDE, J. WOOD, J. MARSALEK AND P. SETO</u>
08:50	Poly(3-Polyhydroxybutyrate) (PHB) Production Using Waste Activated Sludge as a Source of Microorganisms and Wastewater as a Source of Carbon <u>S. YAN* AND R.D. TYAGI</u>	Spill Management Planning in the Toronto AOC J. LI
09:15	Performance of Overland Flow System for Advanced Treatment of Plant Effluents <u>A.T. HARANDI,* R.L. DROSTE AND H. GHODOSI-SHAHREZAI</u>	Refinement of Hydraulic Operation of a Complex CSO Storage Facility by Numerical and Physical Modelling <u>C. HE, J. MARSALEK, Q. ROCHFORT AND B.G. KRISHNAPPAN</u>
09:40	Health Break – Main Mall	
10:00	New Treatment Scheme for Municipal Landfill Leachates <u>K. VOLCHEK, B. WONG, D. VELICOGNA, A. ABENAU, A. DUMOUCHEL, A. SOMERS, C.E. BROWN AND S.R. CATER</u>	Coagulant Survey for Chemically Enhanced Settling of CSOs <u>K. EXALL AND J. MARSALEK</u>
10:25	Use of the Biosor™ Process to Treat Effluents from the Agri-Food Industry. Case Study: Wastewater from a Poultry Slaughtering Plant <u>R. DUBÉ, G. BUELNA AND G. BELLEMARE</u>	Development of a Numerical Simulation Model for High-Rate Retention Treatment Basins used in CSO Applications <u>O. SCHRAA, B. GALL AND D.W. AVERILL</u>
		Session 3 – North/South Seminar Room
Theme		DRINKING WATER QUALITY AND TREATMENT Chair: SUSAN B. WATSON Research Scientist National Water Research Institute
10:50	In situ Remediation of Hexavalent Chromium with Pyrite Fines in Simulated Field Conditions <u>S. CATHUM, C.E. BROWN, A. SOMERS AND W.P. WONG</u>	Inshore Areas: A Primary Source of Taste and Odour in the Upper Saint Lawrence River <u>J.J. RIDAL, M. MAHABIR AND S.B. WATSON</u>

11:15		Cyanobacteria and Drinking Water Odour: Within- and Among-Species Differences Re-Examined, Using Systematic Taxonomic, Experimental and Analytical Protocols <u>S.B. WATSON</u> , H. KLING AND G. IZAGUIRRE
12:00	Lunch – Main Mall	
Room	Session 3 - Auditorium	Session 4 - Guest Lounge
Theme	DRINKING WATER QUALITY AND TREATMENT Chair: SUSAN B. WATSON Research Scientist National Water Research Institute	WATERSHED AND WATER QUALITY ASSESSMENT Chair: ALICE DOVE Watershed Scientist Ecosystem Health Division Ontario Region, Environment Canada
13:00	Removal of Earthy/Musty Odour Compounds from Drinking Water by Biological Filtration <u>S. ELHADI</u> ,* P.M. HUCK AND R.M. SLAWSON	Facilitating Climate Change Impacts and Adaptation Research for Canadian Water Resources <u>B.B. MEHDI</u> AND C.A. MADRAMOOTOO
13:25	N-Nitrosodimethylamine Formation from Amine-Based Polyelectrolytes Used in Drinking Water Treatment <u>K.D. KOHUT</u> * AND S.A. ANDREWS	Application of the CCME CWQI for the Communication of Drinking Water Quality Data in Newfoundland and Labrador <u>A.A. KHAN</u> , R. PATERSON AND H. KHAN
13:50	UV Inactivation of Floc-Associated MS-2 Coliphage <u>M. TEMPLETON</u> ,* R. HOFMANN, R. ANDREWS AND E. WHITBY	Water Quality Strategy for the Credit River Watershed <u>A. HUMPHRIES</u> , H. BRETON AND I. HEATHCOTE
14:15	Health Break – Main Mall	
	Session 5 – Auditorium	
Theme	WATERBORNE PATHOGENS Chair: SUSAN B. WATSON Research Scientist National Water Research Institute	
14:45	Microbial Source Tracking: Antibiotic Resistance Profiling and DNA Fingerprinting of <i>E. coli</i> Isolates for Determining Sources of Fecal Pollution <u>T. EDGE</u> AND S. HILL	Method Development for the Analysis of Waterborne Carbamates, Phenyl Ureas and Organophosphates Pesticides C.Y. HAO, E. CHEN, M. AIELLO AND <u>P. YANG</u>
15:10	Microbial Source Tracking Using <i>Bacteroides – Prevotella</i> 16S rRNA Gene Targets T. MACMILLAN, T.A. GRAHAM AND <u>V.P.J. GANNON</u>	Selection of Inflow Parameters in the Design of Best Management Practices for the Removal of Suspended Sediments and Oil from Urban Runoff <u>P. WISNER</u> AND L. GERVAIS
15:35	Development of a Dual Colour Flow Cytometric Method for the Simultaneous Detection of <i>Giardia</i> Cysts and <i>Cryptosporidium</i> Oocysts M. PARENTEAU, L. PARRINGTON, D. LECLAIR, J. BUSSEY AND <u>B. DIXON</u>	Water Quality Evaluation of a Construction Sediment Pond L. PYATT*
16:00	Environmental Effects on Drinking Water, Waterborne Pathogens and Human Serological Response, the British Columbia Experience <u>J. ISAAC-RENTON</u> , J. PRIEST, A. LI, S. SHAY, C. ONG, M. KHAN AND P. LAMMIE	
16:15	Auditorium: Philip H. Jones Award and concluding remarks by M.N. Lywood	

* Competing for the Philip H. Jones Award.

**POSTER DISPLAYS
(MAIN MALL)**

Poster displays are available in the Main Mall on both Monday, February 10th and Tuesday, February 11th. The authors will be in attendance at their posters during the Poster Social on Monday, February 10th at 16:30.

Session Theme – GROUNDWATER: QUALITY, QUANTITY AND REMEDIATION

Sustainable Water Well Initiative: Evaluation of Electrokinetics to Control Water Well Biofouling
R. GLOBA AND H. ROHDE

Assessing the Impact of the Bioremediation of a Tetrachloroethylene-Contaminated Environment on Amphibian Larvae
T. MCDANIEL, P. MARTIN, N. ROSS, H. STEER, A.-M. IRWIN ABBEY AND S. LESAGE

Evaluation of a Science-Based Alternative Management Practice for the Treatment of Farmyard Runoff and Milk House Washwater
T.L. MCMUNN, D.L. RUDOLPH, W.D. ROBERTSON AND C.J. PTACEK

Density Stratification of a Northern Manitoba Lake Induced by Acid Mine Drainage
M.C. MONCUR, C.J. PTACEK, D.W. BLOWES AND M. HAYASHI

Session Theme – SURFACE WATER: ENVIRONMENTAL EFFECTS

The Impact of Low-Moderate Anthropogenic Disturbance on Alpine Algal Communities
K. CHEEK AND S.B. WATSON

Advances in Genomics and the Environmental Fitness of Genetically Engineered Bacteria
T. EDGE

In-use Pesticide Concentrations in Canadian Tributaries of Lakes Ontario and Erie
J. STRUGER, P. MARTOS, B. RIPLEY, D. BOYD AND M. THORBURN

Session Theme – WATERSHED AND WATER QUALITY ASSESSMENT

Water Quality Hydrodynamic Modelling of Rideau River
S. ASIE, F. PICK AND R. FRENETTE

A Study for Integrated Water Resources Pollution Control in Central Area of Isfahan Province in Iran
A.T. HARANDI, M. KARAMOUZ AND R.L. DROSTE

The Watershed Report Card: A Functional Approach to Watershed Assessment
R.J. MILNE

NOTE: There will be a number of commercial exhibits in the Main Mall including:

- AssayNet Canada Inc.
- Environmental Commissioner of Ontario
- Hanson Pipe & Products Canada, Inc.
- Trojan Technologies Inc.
- Waterloo Biofilter Systems Inc.
- Water Quality and Health Bureau, Health Canada

Surface Water: Environmental Effects

Chair: JOANNE L. PARROTT

Overview of Fish and Wildlife Health Effects and Exposure Studies in Canadian AOCs

SCOTT BROWN,^{1*} JOHN STRUGER² AND GLEN FOX³

¹ *Environment Canada, National Water Research Institute, Burlington, Ontario*

² *Environment Canada, EHD/ECB-Ontario Region, Burlington, Ontario*

³ *Environment Canada, Canadian Wildlife Service, National Wildlife Research Centre, Carlton University, Ottawa, Ontario*

Environment Canada has undertaken studies in Canadian AOCs to measure present concentration of chemicals of established concern, to assess previously unmeasured chemicals in the aquatic environment that could be associated with environmental health outcomes and to determine the current state of fish and wildlife health. Phase One (2001–2005) is focusing on conditions in the Canadian AOCs of the lower Great Lakes. In addition to measuring persistent contaminants such as POPs, novel ways to measure less persistent chemicals and determine environmental exposure are evaluated. Physiological and reproductive effect endpoints have been chosen in fish and wildlife that are fundamental to the functional health of individuals and populations. Evaluated health effects in fish, snapping turtles, birds and mink involving specific endpoints that relate to populations and individual health include wildlife population trends, tests for measuring fish and wildlife reproductive success, tests for status of endocrine systems, tests for assessing components of liver function, tests for measuring immune function and tests for other health effects such as enzymes and other plasma constituents which have diagnostic value. So far, the focus for health effects has been on AOCs in western Lake Erie and the Detroit and St. Clair rivers. Some highlights of findings to date indicate that concentrations of most persistent organochlorine and lead concentrations in adult herring gull tissues have declined over in the last decade. However, there are significant amounts of pyrene-like PAHs in bile of gulls from the Detroit AOC. In trapper-caught mink from the eastern basin of Lake Erie, fewer than 10% of the samples exceeded the lowest observable effects level for reproductive impacts, whereas 100% of samples from western Lake Erie exceeded this level. There has been little evidence of reproductive activity by snapping turtles at the Wheatley Harbour AOC over the past two years and the estrogen-dependant egg yolk protein (vitellogenin) normally produced only by breeding females was also found in adult male turtles. Elevated vitellogenin also occurs in adult male herring gulls from the Detroit River AOC. Thyroids of adult herring gulls are enlarged (goiter) and have a reduced capacity to synthesize thyroid hormones. Overall, the study will help to determine whether a regular, long-term monitoring program assessing fish and wildlife health is needed and help to develop appropriate protocols for such a program.

* Presenting author; scott.brown@ec.gc.ca

Assessment of the Estrogenic Potency of Effluents from Petrochemical Facilities and a Petroleum Refinery in Ontario.

J. SHERRY,^{1*} T. TREPANIER,² C. TINSON,¹ T. MORAN,³ T. KIERSTEAD³ AND S. MUNRO²

¹ *National Water Research Institute, Burlington, Ontario*

² *Sarnia Lambton Environmental Association, Sarnia, Ontario*

³ *Pollutech EnviroQuatics, Point Edward, Ontario*

A previous study demonstrated that wastewater from an Ontario Refinery could induce vitellogenin (Vg), a biomarker of exposure to estrogenic chemicals, in juvenile rainbow trout. Our objective was to reassess the estrogenic potency of the wastewater from that refinery and to also assess the estrogenicity of wastewater from three petrochemical facilities. The effluents were tested in a 21-day static renewal test in which the effluent was fully replaced daily. A competitive binding ELISA was used to detect induced Vg. A replicated tank design was used to allow statistical testing for tank effects. St. Clair River water from upstream of the industrial facilities was used as a negative reference. Waterborne 17 β -estradiol served as the positive control treatment. The results show that the wastewater from the petroleum refinery induced Vg in the treated fish. The wastewater from the petrochemical effluents did not induce detectable levels of Vg in the treated fish. We shall consider these data with respect to the industrial process at each facility and, in the case of the refinery, the potential for possible responses in feral fish.

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National Assessment of Pulp and Paper Mill Environmental Effects Monitoring: Presence of Large-Scale Response Patterns

R.B. LOWELL,^{1,2} J.M. CULP,^{2,3} L.C. GRAPENTINE,⁴ M.E. MCMASTER,^{4*} K.R. MUNKITTRICK⁵ AND
S.C. RIBEY¹

¹ *Environment Canada, National EEM Office, Ottawa, Ontario*

² *Environment Canada, National Water Research Institute, Saskatoon, Saskatchewan*

³ *Department of Biology, University of New Brunswick, Fredericton, New Brunswick*

⁴ *Environment Canada, National Water Research Institute, Burlington, Ontario*

⁵ *Department of Biology, University of New Brunswick, St. John, New Brunswick*

The Environmental Effects Monitoring Program, a national requirement for pulp and paper mills under Canada's *Fisheries Act*, ranks among the largest standardized field monitoring programs in the world. We have analyzed the results to date to help interpret the type and magnitude of effects on benthic invertebrates and fish in freshwater and marine receiving waters. Using a newly developed combination of meta-analytical and multivariate techniques, it was possible to quantitatively integrate the invertebrate and fish data and to identify a number of national response patterns in areas exposed to pulp mill effluent. These national patterns were fully consistent with smaller scale responses described in the literature, allowing us to interpret the results within the context of known mechanisms of effects. The most common effluent-associated effect on benthic invertebrates was one of mild to moderate eutrophication, although there was evidence of more pronounced eutrophication, toxicity, or smothering effects at some mills. The most common effluent-associated effect on fish was a combination of nutrient enrichment and metabolic disruption, although other response patterns were also observed, including differing degrees of nutrient enrichment versus limitation. Multivariate analyses of the meta-analytical output revealed good agreement between the benthic invertebrate and fish results and, at the same time, illustrated how each core endpoint tracked a different aspect of the overall response to effluent exposure.

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Physiological and Biochemical Responses of Small Fish Exposed to Athabasca Oil Sands Sediment

G.R. TETREAULT,^{1,2*} M.E. MCMASTER,² D.G. DIXON¹ AND J.L. PARROTT²

¹ *University of Waterloo, Department of Biology, Waterloo, Ontario*

² *Environment Canada, Burlington, Ontario*

Fish collected from the Alberta Athabasca Oil Sands watershed, including sites off the oil sands deposit itself, were examined. Within two tributaries, fish are either unexposed (reference), or exposed to naturally occurring oil sands related compounds. Wild fish collections and a laboratory sediment exposure were initiated to evaluate the influence of naturally occurring oil sands related compounds on reproductive function (gonadosomatic indices, fecundity, in vitro steroid production capacity) and hepatic responses (7-ethoxyresorufin-*O*-deethylase [EROD] activity). In vitro gonadal incubations demonstrated lower levels of steroid production at the tributary sites within the oil sands deposit. Hepatic 7-ethoxyresorufin-*O*-deethylase (EROD) activity, as an indicator of exposure to oil sands related compounds, was elevated 5-fold at these same sites. In the laboratory, slimy sculpin (*Cottus cognatus*) were exposed to sediment samples from the Steepbank River sites at concentrations of 10 or 20g/L (wet weight), for 4 and 8 d. For the purpose of evaluating EROD induction in fish exposed to oil sands sediment, a time period of 4 d was sufficient to induce what appeared to be maximum induction in this species by these sediments. The EROD activity measured in exposed fish was comparable to that measured in fish native to the oil sands area. This study, as designed, was not capable of predicting an altered ability of gonadal tissue of exposed fish to produce steroid hormones in vitro, as was demonstrated in the wild fish assessment of 1999 and 2000. Future development may further compromise the reproductive health of fish residing in this area.

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Changes in Growth, Secondary Sex Characteristics and Reproduction of Fathead Minnows Exposed for a Lifecycle to Bleached Sulphite Mill Effluent

J.L. PARROTT,^{1*} C.S. WOOD,² P. BOUTOT,² B. BLUNT,¹ M. BAKER¹ AND S. DUNN³

¹ *Aquatic Ecosystem Protection Research Branch, National Water Research Institute, Environment Canada, Burlington, Ontario*

² *NexFor (Noranda Inc) Technology Centre, Pointe Claire, Quebec*

³ *Fraser Paper Inc., Edmundston, New Brunswick*

Wild yellow perch captured downstream of Nexfor Edmundston bleached sulphite mill (BSM) had reduced gonad size and fecundity. Exposures of goldfish to final effluent for 21 days showed decreases in circulating steroid levels. To assess the potential effects of long-term exposure to bleached sulphite mill effluent (BSME), fathead minnow (FHM, *Pimephales promelas*) lifecycle tests were carried out in a flow-through bioassay trailer at the mill secondary treatment lagoons. Exposure concentrations included 0, 1, 3, 10, 30, 50 and 100% final effluent with ethinylestradiol (EE2, 10 ng/L) as a positive control compound. Fertilized FHM eggs were hatched in effluent and monitored through to 30, 60 and 125 days post-hatch. The effluent caused a significant increase in the growth of fish, and this effect could be seen in as little as 30 days at exposure concentrations of 3% BSME and above. At 60 days post-hatch, one of the earliest endocrine-disruption (ED)-specific endpoints was the premature development of ovipositors in fish exposed to 30% BSME. Changes in external sex characteristics and reproduction were very sensitive endocrine-disruption (ED)-specific endpoints, and required four months of exposure. At maturity, fish had changes in secondary sex characteristics, with significantly increased ovipositor index (a feminization) of male fish in effluent concentrations above 30%. Higher effluent concentrations resulted in a majority of fish that looked externally like females. At low BSME concentrations (3%) we saw some female fish that had male sex characteristics (this was not seen in control fish). This masculinization of female fish was statistically significant at 10% effluent. A very sensitive endpoint and probably the most meaningful change observed was a decrease in reproduction. Fish exposed to 1 to 3% BSME produced a similar number of eggs to control fish; however, exposure to 10% BSME reduced egg production by over 80%. Fish exposed for an entire lifecycle to 30% BSME and above failed to produce any eggs. Concentrations of final effluent in the Saint John River range from less than 1% to 10%, depending on the season and river flow. The research demonstrates the feasibility and potential usefulness of on-site flow-through fish lifecycle exposures for the assessment of pulp mill final effluents.

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TerraQSAR™ - FHM, a Probabilistic Neural Network-Based PC Program to Estimate the Acute Toxicity of Chemicals to Fish

K.L.E. KAISER *

TerraBase Inc., Hamilton, Ontario

TerraQSAR™ - FHM is the first probabilistic neural network (PNN)-based stand-alone computer program for the prediction of 96-hr LC50 values for the fathead minnow (*Pimephales promelas*), the most important North American freshwater test fish. It is designed to rapidly produce toxicity estimates for organic and organometallic substances, including their salts.

TerraQSAR™ - FHM is also the first of a series of neural network programs, using the PC Windows® operating system, for the prediction of acute toxicity and sublethal effects of chemicals.

TerraQSAR - FHM has been developed on the basis of measured LC50 values for over 850 substances. The sole input required is a chemical's structure, it does not require any prior knowledge of the use of the substances, their mode of action, or any other non-structure-based information.

All TerraQSAR programs use the SMILES (Simplified Molecular Line Entry System) code for chemical structure input. Computation times vary with the speed of the computer's central processor unit (CPU) and the complexity of the molecular structures under investigation. With a CPU speed of 2 GHz, the results for most substances with 12 carbon atoms or less are computed within 5 to 10 seconds.

The TerraQSAR programs use a proprietary PNN technology, based on well-recognized mathematical principles, and a state-of-the-art SMILES code interpreter for chemical structure recognition and analysis. This presentation gives an overview of the underlying methodology, principles, and applications. Symposium registrants are also invited to a demonstration of the TerraQSAR - FHM program and to obtain estimates for compounds of their choice. For additional information, see also the company's website at <http://www.terrabase-inc.com>.

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Groundwater: Quality, Quantity and Remediation

Chair: NATHALIE ROSS

Regional Scale Assessment of Groundwater Conditions Within the Great Lakes Basin

A.R. PIGGOTT*

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Recognition of the simultaneous societal and ecological functions of groundwater within the Great Lakes basin is increasing. As a result, there is consensus that an improved understanding of groundwater conditions is required in order to ensure the sound management of water quantity and quality through land and water use planning and within the context of the potential impacts of climate change. Research being conducted within Environment Canada's National Water Research Institute in partnership with bi-national, federal, provincial, and local agencies is contributing to the development of this improved understanding. The approach that is being used is practical and relies on the compilation, analysis, and interpretation of existing hydrometric, climatic, and landscape data and the creation of research results that fulfill the requirements of multiple stakeholders. Archival stream flow and climatic data are being used to determine the dynamics of groundwater and climate interaction, which can then be combined with climate change scenarios to predict the potential impacts of this change on groundwater conditions and therefore on water supplies and in-stream conditions. Existing geologic data, water well construction information, and various data describing the landscape of the basin are being used to extrapolate this understanding beyond the discontinuous network of hydrometric monitoring in a manner that is both consistent and seamless. Results achieved to date for western southern Ontario illustrate the substantial temporal and spatial diversity of groundwater conditions. For example, the portion of precipitation that is available to recharge the groundwater flow regime is both temperature dependent and seasonal, varies from 75 percent during the winter to 10 percent during the summer, and is less during the fall than during the spring. This result highlights the sensitivity of surface and subsurface flow to changes in the annual pattern of precipitation. The results also indicate that groundwater discharge forms between 10 and 80 percent of total annual stream flow, with a regional average of 40 percent. The resilience of this discharge is equally diverse and is critical to maintaining aquatic habitat during periods of drought that may be a proxy for future climatic conditions. Significant challenges will be encountered during the extension of these findings basin-wide. Methods of stream flow analysis that are a fundamental element of the research may not be as applicable in regions where delayed flow through wetlands and lakes masks groundwater discharge. Water well construction information, and perhaps metrics of the landscape, may be less readily available in more sparsely populated portions of the basin. Ensuring the consistency of descriptions of groundwater conditions across jurisdictional boundaries will require agreement on, and very likely revision of, prevailing methods of data analysis and interpretation. Finally, linking physically based descriptions of groundwater conditions to ecological factors and representing naturally occurring and human-induced water quality constraints will require significant inter-disciplinary collaboration.

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City of Guelph Response to Ontario Regulation 459/00 – Drinking Water Protection Regulation

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Acres & Associated Environmental Limited (A&A) developed a protocol for determining groundwater under the direct influence (GUDI) status to assist the City of Guelph in the assessment of treatment requirements for their municipal water supply. This protocol is based on protocols established by the U.S. EPA and further defined in AWWARF Project #605. The protocol entails three stages of assessment. Stage 1 is a review of existing information in order to characterize the well as a true groundwater (GW) or groundwater under the influence of surface water (GUDI). This data includes well construction and maintenance records, sanitary condition of the well, hydrogeological data including time of travel estimates (well-head delineation), geological characteristics and water quality data. Stage 2 is initiated if there is insufficient data to make a characterization of the nature of the well in Stage 1 and consists of a period of data collection that will allow the characterization to be completed. Wells that are characterized as GUDI are then subject to a Stage 3 assessment which consists of a data collection period followed by an assessment of the level of natural or in situ filtration which is occurring. If sufficient evidence of in situ filtration is shown in the Stage 3 assessment, then a case can be made for waiving the chemically assisted filtration component of the minimum treatment requirement for GUDI in the Province of Ontario. Minimum treatment requirements in the Province of Ontario for GUDI sources with effective in situ filtration is 3-log *Giardia*, and 4-log virus disinfection.

The City of Guelph supply system consists of a network of 21 groundwater wells and a spring collector system, augmented by artificial recharge. The Stage 1 assessment was completed for all of the City's wells as a part of the Provincially mandated engineers' report. Three well systems, Burkes, Downey and Carter #1 and #2 were identified as requiring a Stage 2 assessment due to insufficient existing data. The collector system (Arnell Spring and Glen Collector) was identified as GUDI by definition and required a Stage 3 assessment. The City of Guelph decided to expedite the process and collect data required for a Stage 3 assessment for the three wells as well as for the surface water recharge and collector system in case the wells were determined to be GUDI.

The results of the GUDI assessment were presented at a stakeholders meeting with key provincial regulators. Consensus was reached as follows:

- Burke Well and Downey Well are representative of true groundwater supplies and as such, must provide disinfection as mandated by the DWPR (15 minutes T₁₀ contact with a minimum free chlorine residual of 0.2 mg/L).
- The treatment requirement to provide chemically assisted filtration for the Carter Wells, the Arnell Recharge System and the Glen Collector System should be waived as effective natural in situ filtration is provided through the subsurface. As such, the treatment requirements for *Giardia* cysts (3-log inactivation) and viruses (4-log inactivation) may be provided by disinfection only.

The City of Guelph has received verbal approval and awaits formal written approval from the MOE in the form of an amended Consolidated Certificate of Approval (CCoFA).

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Establishing GUDI Status and Quantifying the Level of Natural In situ Filtration: Microscopic Particulate Analysis (MPA) Used in Conjunction with Hydrogeology Principles by the Greater Cincinnati Water Works

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Since the promulgation of the U.S. EPA Surface Water Treatment Rule (SWTR), regulatory agencies have required groundwater sources receiving localized recharge from surface water to be evaluated for “ground water under the direct influence of surface water” (GUDI). The determination is made, in part, using an analytical procedure called microscopic particulate analysis (MPA). This procedure identifies the occurrence of surface water indicators such as algae and diatoms in groundwater sampled from a pumping well. If these microorganisms occur repeatedly and in significant numbers, the groundwater is thought to be at risk for *Giardia lamblia* and *Cryptosporidium parvum*. Groundwater sources designated as GUDI are required to provide treatment equivalent to that required for surface water including chemically assisted filtration and disinfection.

Over a ten-year period, the Greater Cincinnati Water Works (GCWW) periodically sampled ten production and ten monitoring wells for MPA, *Giardia* and *Cryptosporidium*. Intensive monitoring was conducted for a one-year period at ten “flowpath wells” and two production wells as part of a large cooperative “Flowpath Study” with the U.S. Geological Survey. The wells, located in a highly productive outwash aquifer, receive recharge from the Great Miami River via induced infiltration. MPA samples were analyzed using the U.S. EPA Consensus Method. *Giardia* and *Cryptosporidium* were analyzed using the EPA ICR Method and Method 1623. Algae and diatoms were found in 57% of 128 groundwater samples. Total algae ranged from 2 to 1.2×10^7 cells/100 gallons. Of 285 groundwater samples collected and analyzed for *Giardia* or *Cryptosporidium*, no pathogens were detected. No correlation existed between *Giardia* or *Cryptosporidium* and other surface water indicators. The data suggest that, even though there is hydraulic influence, riverbank filtration is highly effective in removing pathogenic protozoa.

In August 2000, in response to an outbreak of *E. coli* O157:H7 in Walkerton, Ont., earlier in the year, the Government of Ontario announced Operation Clean Water and promulgated the new Drinking Water Protection Regulation (DWPR)—largely based on the U.S. EPA SWTR. Utilities and engineers have been actively engaged in characterizing source water supply status—surface water, groundwater, or GUDI—and identifying the accompanying level of necessary treatment. It is widely accepted that natural in situ filtration can provide substantial reductions in the concentrations of both microbial and chemical contaminants. However, at this time, the Province has yet to establish guidelines for quantifying the level of natural in situ filtration that may be available through the subsurface and accept that this is an acceptable treatment technology. These processes are challenging and from our past decade of U.S. experience, this process should be approached as a collaborative effort involving expertise from hydrogeology, water quality and process engineering.

The GCWW is most applicable to the current GUDI situation in Ontario. This study will provide useful information to regulators and water supply professionals within the Province regarding the direction and development of best-practice protocols for assessing and characterizing source water supply status, as well as determining if effective treatment is available via natural in situ filtration through the subsurface.

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Contamination of Groundwater by DDT at Point Pelee National Park, and Potential Risks to Ecosystem and Human Health

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Until the early 1970s, much of Point Pelee National Park (PPNP) was occupied by agricultural land use activities including vegetable fields and fruit orchards. DDT was used extensively from 1948 to 1967 within these agricultural areas to control insect pests. The natural soil and hydrological conditions within the Park have allowed DDT and its daughter products DDE and DDD to persist within the shallow soil in many areas of PPNP much longer than expected. Surficial soil analyses have shown total DDT concentrations up to 87,520 ng/g. Localized high concentrations of DDT within former orchard areas have brought into question the possibility that DDT may be leaching from ground surface to the water table. Further concern surrounds (1) the potential migration of DDT within groundwater to the marsh and its subsequent impact on the marsh's plant and animal communities, and (2) the potential for DDT to enter the Park's drinking water supply wells.

To assess concentrations of DDT in groundwater, sixteen groundwater samples of twenty litres were obtained from the water table using a temporary stainless steel drive point sampling apparatus and analyzed for the presence of DDT, DDE and DDD. Surficial soil samples were collected at the groundwater sampling sites and also analyzed for DDT, DDE and DDD. Groundwater concentrations of total DDT ranged from below detection limits (<0.1 ng/L) to 0.548 ng/L. Although soil concentrations at the orchard scale are highly variable (3.19×10^2 to 8.75×10^4 ng/g) over hundreds of metres, at our smaller groundwater sampling site scale, concentrations were very similar (14,481 to 19,773 ng/g) over a distance of 3 metres.

Groundwater concentrations were also shown to be orders of magnitude less than surface soil concentrations. The comparison of shallow soil concentrations with groundwater samples extracted directly below showed that no apparent relationship exists between concentrations of DDT at the surface and DDT concentrations in groundwater. However, the relative ratios of the compound DDT to DDE and DDD are the same in groundwater as in the overlying soil. The lower groundwater concentrations are due to the high adsorption of DDT to organic matter in shallow soil horizons, and thus, there is little chance that DDT will leach through the soil column to the water table.

To assess the possibility that the Park's drinking water supply wells were contaminated, twenty-litre samples were obtained from seven supply wells. Groundwater concentrations of total DDT from drinking water wells ranged from below detection limits (<0.005 ng/L) to 0.483 ng/L, or several orders of magnitude below OMOEE drinking water guidelines of 50 ng/L DDT (OMOEE 1997).

Although concentrations in shallow soil are above Canadian Soil Quality Guidelines (CCME 2001) in some areas of the Park, the groundwater concentrations are extremely low and well below OMOEE Drinking Water Guidelines (OMOEE 1997). Thus, there is little risk of DDT, DDE and DDD leaching to the water table and consequently, little chance that DDT dissolved in groundwater will impact either marsh communities or human health through the groundwater pathway.

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Removal of Arsenic from Contaminated Water Using Coagulation Enhanced Microfiltration

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This paper describes results of an experimental evaluation of an innovative arsenic removal process that incorporates coagulation and microfiltration. The Coagulation-Enhanced Microfiltration (CEMF) was studied with respect to groundwater treatment, given the increasing importance of the arsenic contamination issue in sources of potable water.

A majority of experiments were carried out on a bench scale using tap water spiked with arsenic, with the addition of ferric chloride that is commonly used in a number of arsenic removal processes. A series of tests were performed on actual arsenic-contaminated water from a former mining site in Ontario.

Test results revealed high arsenic removal efficiency, using both spiked solutions and the actual water from a former mining site. It was found that CEMF could be a viable addition to the existing arsenic removal schemes. The incorporation of microfiltration in the treatment process as a polishing step would significantly reduce the level of residual arsenic in the treated water.

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Ralgreen Restoration Project

A Brownfield Cleanup in a Residential Neighbourhood

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The Ralgreen Community is a residential neighbourhood in Kitchener, Ontario. In the late 1940s, prior to residential development, the owner of the lands entered into an agreement with the City of Kitchener to fill in a pond to gain additional farmland. From 1948 to 1950, the pond was used as a municipal waste disposal site. The site was then re-graded and put back into agricultural production. In the late 1960s, the property was sold to a developer, who serviced it for development as the Ralgreen community, with semi-detached homes and townhouses.

Evidence of environmental impacts from waste disposal activities arose shortly after construction activities began. In 1996, a number of residents of Ralgreen Crescent notified the City about concerns of excessive building settlement, seepage of liquids into basements and indoor odours. In 1997, the issues raised by the residents—and the \$65-million lawsuit they filed against the City—received national media coverage as the focus of a CBC Fifth Estate episode.

After a series of environmental investigations, the City reached a mediated settlement in the lawsuit that included an agreement to undertake an environmental restoration process in accordance with the Ministry of Environment's "Guideline for Use at Contaminated Sites in Ontario" (MOE 1997 Guideline). Under this agreement, the City retained Frontline Environmental as a remediation specialist and purchased a total of 27 homes, with most affected homes directly over the former pond.

Frontline's work on the Ralgreen Restoration Program included:

- Delineation of the former pond and waste;
- Characterization of the types of waste;
- Determination of soil and groundwater quality characteristics; and
- Assessment of geological and hydrogeological environment in the study area.

Past studies were reviewed and assessed for historical, geological and chemistry data. A drilling and soil sampling program was undertaken to delineate the limits of the former pond and the waste disposal limits. A hydrogeological assessment of the shallow groundwater system was undertaken to identify groundwater quality and movement. Homes in the area were also structurally assessed.

Results for soil quality determined that several chemical compounds were present at levels above the MOE Table A Residential/Parkland Criteria within the waste matrix including petroleum hydrocarbons, benzene, toluene, ethylbenzene, xylenes, and polynuclear aromatic hydrocarbons (PAHs). A soil excavation and separation/disposal program was initiated to manage approximately 70,000 m³ of impacted materials.

Groundwater in the study area was located within 5 metres below ground surface and easterly flowing. Groundwater impacts included tetrachloroethene, petroleum hydrocarbons and PAHs. Impacted groundwater was managed during the soil excavation and replacement program. There was no evidence of affected groundwater migrating from the source area.

With waste layers reaching depths of 7.9 metres below ground surface and extending beneath homes and roadway, beyond the confines of the original pond, Frontline recommended the demolition of 20 homes in order to clear the environmental work area for excavation and remediation.

The site is nearing completion of the restoration process with new services installed for new dwelling units and re-landscaping of the adjacent residential properties started.

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Surface Water: Modelling and Microbes

Chair: CHRIS MARVIN

COMPETING FOR THE PHILIP H. JONES AWARD

Techniques and Protocol for Watershed-Level Calibration of an AnnAGNPS Simulation

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A study examining the potential benefits on stream quality of employing agricultural best management practices in the South Nation watershed was conducted. The watershed is vast and includes a wide variety of land uses and soil types, notably with respect to agriculture and forestry. Non-point sources, particularly agricultural, contribute significant pollutant loadings to the South Nation River. The study employs the use of computer models and geospatial data to simulate watershed processes and compute water quality parameters for several historical weather scenarios.

The Annualized Agricultural Non-Point Source (AnnAGNPS) computer code is a continuous-simulation pollutant-loading model developed by the U.S. Department of Agriculture (USDA) for watershed-level analysis. This model is among the most commonly used models for dynamic simulation of agricultural impacts on surface water quality. Data input requirements are extensive, with over 400 parameters required for model execution. The code is organized into “modules” that simulate a wide variety of watershed processes.

Although it is a widely used and well-respected model there is little information available in the literature on governing features or a calibration protocol for AnnAGNPS. An in-depth examination of the sensitivity of AnnAGNPS parameters was first conducted on an artificially simplified scenario, to assess model behaviour and validity. The work conducted during this initial phase of the work led to a basic sensitivity analysis of the code, as well as the uncovering of several recommendations for model calibration. Subsequently, the “real-world” watershed-level scenario was assembled, with over 3000 cells and a wide variety of land and soil uses were simulated at high resolution compared to previous studies that only divided the region into 100 or so cells and were often limited to single event simulations. A variety of tools were developed to avail the model of electronic topography data, land use, and soil type data among other required inputs and facilitate the conduct and data processing from thousands of runs. Previous analyses of the watershed have been limited by using a coarse grid of approximately 100 cells, or single event simulations. A further calibration and sensitivity analysis was then conducted on the second, “elaborate” scenario. The second sensitivity analysis therefore considered a variety of phenomena not possible or desired under the “simple” scenario. This paper discusses the results of both the simple and elaborate analyses, and the emergent behaviours and implications for calibration of the model. A revised watershed-level calibration protocol for the AnnAGNPS model is also included, and calibration techniques examined.

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Pollution Studies on Surface Water of the Southwest Coastal Plain of the Caspian Sea Area: A Case Study of the Syahrood Watershed in Central Gilan, North of Iran

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The southern coast of the Caspian Sea is primarily along the northern territory of Iran. This coastal region is the most popular recreation site due to the beaches and it is one of the most populated provinces of the country because of its rich natural resources. The high levels of urbanization, agriculture, industrialization and the tourist industry in the south of the Caspian Sea has kept its waterways highly polluted. Therefore its pollution will affect not only the residents and the ecosystem but it also has negative impacts on over two million visitors during the summer, negatively impacting the economics of the region. In order to identify the nature, sources, and extent of this pollution, various physical, chemical and biological parameters of the surface waters were determined in samples collected during the four seasons in 2002. One of the most polluted waterways is the Syahrood (the Persian word for Black River) and it was selected for this study after a field examination considering geology, land uses, industrial locations, and rural and urban areas. After field examination and help of a false colour composite from LandSat ETM⁺ image from June 2000 and considering accessibility of the sites, the sampling stations were selected. I LWIS-GIS software was used for data processing in GIS environment. The discharge rates were measured at ten sampling stations along the river system from upland to the seashore. The water samples were analyzed for physical parameters such as temperature, turbidity, and TDS. The chemical parameters such as pH, EC, COD, cations, anions, and some important heavy metals were analyzed on the water samples. Biological parameters such as total coliforms, fecal coliforms, and BOD₅ also were determined. All the determinations were done on the samples collected for four seasons in the year 2002 and comparison is made between the seasonal results, world averages for river waters and international and Iran EPA water quality standards. It is concluded that the waterway's pollution is due to the complex matrix of the land use, industrialization, urbanization and agriculture in this highly populated area; however, the study indicated the major land uses are responsible for much of the pollution measured. One of these land uses is the municipal landfill site that the watershed management authorities and municipalities should consider for any pollution control planning.

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Lake Sediment Structure and Evolution (LSSE) Research: Towards Predictive Reaction Transport Models

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The LSSE collaboration is an NSERC Strategic Project involving principal investigators at the universities of Ottawa and Victoria, the Geological Survey of Canada (GSC), Natural Resources Canada and at several other institutions along with several graduate students and postdoctoral fellows (www.science.uottawa.ca/LSSE). The main goal is to develop predictive reaction transport models (RTMs) of lake evolution and responses to natural and anthropogenic changes. A sediment early diagenesis RTM is based on interconnected sets of chemical reactions and transport processes that describe the spatially continuous dynamics of both the solid and dissolved species in the sediment and its porewater that are in contact with the water column. A main study area involves one hundred lakes within a 100-km radius area around the Horne smelter at Rouyn-Noranda, Quebec. Observations and model results from the last two years will be presented in four focus areas: (1) phosphorus cycling and resuspension events related to algal blooms, (2) organic matter and its degradation, (3) sediment buffering mechanisms of lake water pH, and (4) unusual iron redox depth profile patterns and their possible causes. LSSE is also involved in (1) developing tools of general interest to aquatic biogeochemists, such as our dSED database of Sediment Early Diagenesis reactions and mechanisms that will be described, and (2) applying several advanced materials characterization methods to sediments that have rarely been used in lacustrine geochemistry.

As an illustrative example, the factors determining lake water pH (3.7–9.1 range) will be described in the light of our measurements and GSC data (Kliza and Telmer 2001, GSC-MITE Phase-I Open File: lake sediment studies in the vicinity of the Horne smelter in Rouyn-Noranda, Quebec). Although the smelter is a strong point source of metal sulphides and acid deposition, we find no correlation between lake water pH and proximity to the smelter. We also find no correlations between lake water pH and catchment area, predominant rock type or predominant vegetation type. In examining the available chemical data (main, trace, heavy and light elements) for both surface and pre-industrial sediments and for the sediment porewaters, the only statistically meaningful correlations involving lake water pH are those with sediment Ca and porewater Ca, that are also correlated to each other. The main Ca-bearing mineral phases detected by long scan (10 hours) X-ray diffraction are the usual Ca-feldspars and minority calcite, Ca-bearing amphibole and epidote. The latter phase is also quantified by ⁵⁷Fe Mössbauer spectroscopy. We conclude that an important pH buffering mechanism is cation exchange with organic matter (OM) Ca in these OM rich (12–74% dry weight) sediments. Ca is a key nutrient of land plants that are the main contributors to our sediment OM (C/N = 11.5[5] weight basis).

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COMPETING FOR THE PHILIP H. JONES AWARD

Estimation of Atrazine Loss through the Surface Runoff in the Lake Erie Basin

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There have been growing concerns over the negative effect of pesticide usage on human health and environmental sustainability. It has been found that atrazine, a widely used herbicide, threatens ecosystems, and the agricultural pollution may even reduce human sperm count. The residues after pesticide application can be discharged into water bodies, which results in deterioration of surface water quality and poses a high potential risk to public health.

An integrated modelling system was developed and applied to estimate atrazine loss in the surface runoff after the application. This model includes a distributed hydrological model, a soil leaches model, relational databases, and geographic information system (GIS). The grid cell concept was introduced into the model system. To reflect this spatial distribution feature, the study area can be divided conceptually into a number of grid cells, each being uniform with respect to vegetation species, soil type, hydrological conditions, topological characteristics, etc. A grid system with 10 km × 10 km resolution was built to cover the study area and became the basic simulation unit for the proposed model. Each grid cell was treated as a unit for atrazine behaviour with inflows from and outflows to other grid cells. The information of soil characters, atrazine usage and basin natures are digitized and gridded using GIS, put in a database, and ready for use by the mathematical model. By using these data, the proposed model can calculate the atrazine losses due to runoff by considering the emissions, chemical and biological degradation of atrazine, adsorption and desorption of atrazine to and from soil particles, and the movement of atrazine in the dissolved and adsorbed phases in the upper soil layer. All results from the model are output to the database and graphically displayed in GIS.

This model was applied to estimate the atrazine loss in the Lake Erie Basin and provide gridded atrazine loads in the study area. During the simulation process, the potential pathway of atrazine movement through runoff and up soil layers as a result of manure application practices can be identified quantitatively. The comparison between the measured data and the predicted results proved the feasibility and acceptable accuracy of the proposed model. The results have shown the values for helping the study on budget determination of atrazine amongst crops, air, surface water and soil in Lake Erie. This research provides a detailed situation of atrazine pollution in the studied basin, which may directly benefit both water quality management and urban/suburban communities by improving pesticide management and reducing water quality burden.

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Toxicity and Estrogenic Activity Reduction of Aqueous Solutions of Alkylphenols Using Peroxidase Enzyme

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Alkylphenols, including 4-nonylphenol (4-NP) and 4-octylphenol (4-OP), have been shown to be highly toxic and moderately endocrine-disrupting compounds in a variety of in vivo and in vitro assays. Due to their high hydrophobicity and relative resistance to biodegradation 4-nonylphenol and 4-octylphenol tend to bind to particles and sediments and to accumulate in living biomass. These findings have raised concern over the long-term effects of these types of compounds on the reproductive health of wildlife and humans and substantiate the need to develop treatment processes to accomplish their removal from wastewaters. Horseradish peroxidase (HRP) is an oxidative enzyme that catalyzes the oxidation of phenols and aromatic amines with hydrogen peroxide to their respective radicals, which undergo further non-enzymatic reactions leading to the formation of phenolic dimers and polymers of decreased aqueous solubility. HRP is characterized by its stability and ability to catalyze phenol conversion over broad ranges of pH and temperature. Numerous studies have confirmed the potential of HRP for the treatment of a variety of phenols, including chlorinated or methylated phenols, and naphthols, anilines and benzidines. It has also been demonstrated that treatment can be accomplished in industrial wastewaters characterized by high concentrations of heavy metals, salts, and suspended solids.

An investigation was conducted into the feasibility of using HRP to accomplish the treatment of estrogenic alkylphenols. The objectives were to investigate whether the alkylphenols, 4-NP and 4-OP, can be treated with HRP and hydrogen peroxide and to determine the impact of the enzymatic treatment on the toxicity and estrogenicity of 4-NP reaction mixtures. Experiments were conducted to treat 3.5 and 6.0 mg/L solutions of 4-NP and 4-OP, respectively. Results demonstrated that aqueous 4-NP and 4-OP can be successfully transformed with HRP and H₂O₂. No 4-NP or 4-OP removal was observed when either the peroxidase or the H₂O₂ were omitted from the reaction mixture. Thus, the conversion of the phenols was due to a combined action of HRP and H₂O₂. Treatment of the phenolic substrates required about 1 mole H₂O₂ per mole of phenolic compound. The Microtox acute toxicity assay was used to quantify toxicity and the yeast estrogen screen (YES) reporter gene assay was applied to measure estrogenic activities of treated and untreated solutions. Recommendations for modification of the YES assay method were made based on observations in this study. Results from experiments involving the treatment of 4-NP showed that HRP-treatment led to complete detoxification of the reaction solution. In addition, the results of the YES assay demonstrated that reaction products resulting from the HRP-catalyzed conversion of 4-NP lacked estrogenic activity. Based on this study, it is concluded that the treatment of alkylphenols can be accomplished using HRP and hydrogen peroxide. Further study is required to determine how well this treatment process will perform in a real waste environment where the alkylphenols may be present in concentrations that are low relative to other contaminants.

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The Microbial Degradation of Common Plasticizers

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In addition to their polymeric components, most plastics contain a variety of low molecular weight additives called plasticizers, which are needed to produce workable final products. Human populations are subject to significant exposure to these compounds as a direct result of the widespread use of plasticizers in many products such as construction materials, automotive parts, medical supplies, household products, toys and packaging. In previous studies, it has been established that plasticizers leach out of plastics into the environment. Compounds such as di-(ethylhexyl) phthalate (DEHP), the most commonly used plasticizer, are now ubiquitous and are found in many ecosystems including rivers, lakes and soil.

Our bench-scale reactor experiments have shown that DEHP and bis (2-ethylhexyl) adipate (BEHA) are readily degraded to metabolites such as 2-ethylhexanol (2-EH). This can be further oxidized to 2-ethylhexanoic acid (2-EHA). As the plasticizers were being degraded, we observed an increase in the toxicity of the aqueous phase, as measured by Microtox acute toxicity assay. It was shown that this rise in toxicity could be attributed to the accumulation of 2-EH and 2-EHA, which were resistant to further degradation. The toxicity of these compounds was also confirmed using *Daphnia*, trout, and fathead minnow environmental toxicity tests.

Preliminary testing of creek, river and soil samples have demonstrated the presence of DEHP, BEHA, 2-EH, and 2-EHA. This demonstrates the resistance to further degradation of the metabolites that was observed in the laboratory and confirms earlier reports of the presence of the plasticizers in these types of environments.

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Photolysis of Naphthenic Acids in Natural Waters

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Naphthenic acids are toxic and corrosive substances in oil sands leachates and are, therefore, priority substances impacting on aquatic environments. As a group, naphthenic acids comprise a large collection saturated aliphatic and alicyclic carboxylic acids in hydrocarbon deposits (petroleum, oil sands bitumen and crude oils). Naphthenic acids enter surface water systems primarily through effluent discharge, but also through groundwater mixing and erosion of riverbank oil deposits. Of the possible environmental receptors (i.e., air, soil, and water), the most significant is water due to direct contact with oil sands material. Ambient northern Alberta rivers in the Athabasca Oil Sands, but unaffected by the oil industry, contain concentrations of naphthenic acids below 1 mg/L. However, tailings pond waters may contain as much as 110 mg/L. Due to the complexity of the natural naphthenic acids in petroleum deposits, they pose an analytical challenge as reflected by the several techniques reported for quantitation of naphthenic acids in the environment. Although naphthenic acids are known to be persistent biomarkers used in identification of oil source maturation, little is established regarding the relative degradation pathways of the compounds.

Other than a general knowledge of environmental persistence, the fate of naphthenic acids in aquatic systems has been sparsely studied. A variety of photolytic degradation techniques were applied to naphthenic acid mixtures and individual compounds to determine the efficacy of UV/vis radiation for reducing both concentration and toxicity of naphthenic acids in the laboratory. The results show that while natural and artificial solar radiation are not capable of significantly reducing either concentration or toxicity of naphthenic acids, photolysis at the UV₂₅₄ treatment wavelength was more successful. Toxicity was assessed using aryl hydrocarbon assay.

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Surface Water: Nuisance Algae

Chair: BIN ZHU

***Cladophora*, an Alga Fouling Great Lakes Shorelines**

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The cycle of growth, detachment and shoreline fouling by the benthic alga *Cladophora* has been a feature of the lower Great Lakes for decades. Reductions in phosphorus loadings in the 1970s reduced the extent of the *Cladophora* problem, however, *Cladophora* continues to be abundant in certain areas of Lake Ontario and Lake Erie. Phosphorus is thought to be the nutrient limiting growth of *Cladophora* and nutrient enrichment is suspected in nearshore areas where *Cladophora* is abundant and fouls shoreline, however, additional factors also influence accumulation of biomass in an area. *Cladophora* requires hard substrate for attachment and shore fouling is often associated with locations where there are extensive areas of rocky lake bottom. Dreissenid mussels are typically abundant on the hard substrate on which *Cladophora* grows and may enhance *Cladophora* growth. The high water clarity frequently observed over mussel beds due to filter-feeding by mussels may promote more extensive algal growth with depth than in the past. Dreissenid mussels may also augment nutrient levels in the *Cladophora* beds. A better understanding of the ecology of *Cladophora* in lakes impacted by dreissenid mussels will assist in addressing concerns related to nutrient pollution and proliferation of *Cladophora*.

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Are Dreissenids Responsible for the Recent Increase of Potentially Toxic Cyanobacterial Species in Lake Erie?

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In recent years, there has been a growing concern about Lake Erie trophic status as phytoplankton biomass seems to have increased during the last couple of years. There have also been more reports on the occurrence of potentially toxic cyanobacterial species such as *Microcystis aeruginosa*. It has been stipulated that the observed changes in phytoplankton communities may have been caused by the dreissenid mussel invasions of Lake Erie. Small-scale studies have shown that zebra and/or quagga mussels can increase nutrient availability and hence increase phytoplankton growth and possibly promote a selective growth of toxic cyanobacterial species. In the summer of 2002, we have used a new in situ fluorometric method (Fluoroprobe) to estimate phytoplankton biomass and composition during several cruises on Lake Erie. Although highly variable, phytoplankton biomass was generally high across the entire lake but was especially high in the Central and Western basins. This is consistent with recent reports stating that Lake Erie may be becoming as productive as it was in the early 1980s. High biomass of potentially toxic cyanobacterial species, mainly *Microcystis aeruginosa* and *Anabaena spp.*, were found at several locations in the Western and Central basins and may be indicative of the recent eutrophication problems in Lake Erie. Results from the 2002 summer cruises will be discussed and potential explanations proposed.

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An Update on Analysis of Algal Toxins from Algae, Fish and Duck Species In and Around Lake Winnipeg

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Incidences of cyanophytes that produce Microcystin in small eutrophic prairie pot-hole lakes and farm dugouts is historically documented. Some of these same species of algae appear in Lake Winnipeg and other large lakes in the area. In 1999, 2000 and 2001, data on toxin presence in water samples, fish tissue and bird tissue was gathered by piggybacking onto presently occurring research. *Aphanizomenon*, *Microcystis* and *Anabaena* species were found in uni-algal and mixed bloom proportions in some of the water samples collected. By utilizing resources available in our lab (Taxonomic knowledge, HPLC with UV/VIS detection and Rapid assay kits), we began to explore toxin presence in these algal blooms and to try and examine toxin transference up the food chain.

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Natural Transformation of *Pseudomonas* spp. Isolated from Water Samples

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One of the ecological concerns regarding the commercial release of genetically modified organisms (GMO) is the potential horizontal gene transfer (HGT) of transgenes from GMOs into indigenous microorganisms. After taken up by microorganisms, the genetic elements contained in extracellular DNA fragments could contribute to a broader genetic adaptation for host microorganisms, such as antibiotic resistance, which could further spread among microbial communities. This has been considered a major mechanism by which microorganisms could develop multi-antibiotic resistance in the environment. Some genera of bacteria capable of taking up extracellular DNA from the environment have been reported, one of these is *Pseudomonas* species. This research was designed to investigate the natural transformability of *Pseudomonas* spp. isolated from different water samples (e.g., pond, river, lake, etc.) in Saskatchewan and ultimately to identify the potential hot spots of natural transformation in these aquatic ecosystems where horizontal gene transfer would be most likely to occur. One hundred and twenty isolates of *Pseudomonas* spp. were isolated from 20 different water samples on the selective culture media for *Pseudomonas* spp. and were further confirmed with the amplification of a highly specific fragment of this genus by polymerase chain reaction (PCR). Of these 120 isolates, 9 isolates (representing 9 sampling sites) were shown to be capable of taking up the extracellular DNA when a plasmid containing kanamycin and gentamycin resistance genes was used as transforming DNA. The frequency of transformants showing resistance to both kanamycin and gentamycin was about 10^{-9} to 10^{-6} per cell. Furthermore, 16S ribosomal RNA gene of these isolates was amplified by specific primers and digested by restriction enzymes (RsaI, HhaI and HaeIII) to characterize the phylogenetic relationship among these isolates, the similar restriction enzyme digestion patterns showed that they are closely related. The results from this study demonstrated that *Pseudomonas* spp. capable of taking up extracellular DNA could be widespread in the environment; a broader investigation needs to be conducted to monitor the potential natural transformability (horizontal gene transfer) in the ecosystems where GMOs were released or are being considered to release.

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Method Development for Microcystins in Environmental Samples

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Algal blooms generated in rivers, lakes and other water sources are responsible for taste and odour problems as well as toxic effects on aquatic and human life. These algal blooms are known to produce neurotoxins, such as anatoxin and saxitoxin, in addition to the heptatotoxins, microcystin and nodularin. Thus, algal toxins form a threat to human health and compromise water-related activities including the drinking water industry, fisheries, aquaculture and tourism. For this reason, in consultation with our divisional clients, it was the intent of our laboratory to devise an analytical method to enable the identification of exposure routes to man and the assessment of toxin levels.

Our goals were to develop a selective method for free microcystin-LR (MCYST-LR) in surface water based on liquid chromatography-(electrospray ionisation) mass spectrometry (LC-[ESI]MS), to make our methods compatible with single quadrupole and ion trap mass spectrometers, to expand the analyte list to include MCYST-RR, -YR and -LA, to develop a method for total microcystins (i.e., free + intracellular) and to investigate the use of tandem mass spectrometry (MS/MS) for additional selectivity. MCYST-LR in water was isolated on octadecyl-functionalised (C18) silica gel, chromatographed on a C18 column with a mobile phase consisting of water, methanol, 0.1% TFA and analyzed by (ESI)MS on a VG ZAB-EQ tandem hybrid mass spectrometer tuned to 1000 RP. The internal standard was Gramicidin S, a cyclic decapeptide antibiotic. The ions monitored for MCYST-LR and Gramicidin S were the singly protonated molecular ions at m/z 996 and m/z 1142, respectively. This method was subsequently modified to include MCYST-RR, -YR and -LA and nodularin. Because of the limitations of voltage switching on a magnetic sector mass spectrometer, baseline chromatographic separation was required between the doubly-charged MCYST-RR and the singly-charged nodularin and other microcystins. The method was subsequently transferred to a newly acquired Micromass Quattro Ultima triple quadrupole mass spectrometer which did not have this limitation. A Kromasil C18 column was used on this instrument. The sample preparation procedure was modified for total microcystins (free + intracellular).

The analysis of real samples for total microcystins demonstrated that chemical noise was a problem with methods utilizing only a single stage of mass spectrometry and therefore, these samples required re-analysis by MS/MS. Over 100 samples have been analyzed for total microcystins and MCYST-LR, -RR and -YR have been detected in 2 locations.

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Wastewater Treatment

Chair: MANO MANOHARAN

Extracellular ATP: A New Early Warning Tool to Detect Stress in Activated Sludge Microorganisms

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ATP (adenosine triphosphate) is the life-essential compound used by cells to store and transmit energy. In activated sludge environments, ATP is often thought to be present only within microorganisms. However, during a 44-day monitoring period of a municipal activated sludge process, the extracellular or dissolved ATP content of reactor samples ranged from 14 to 407 ng/mL. It was also found that the ratio of dissolved ATP to total ATP (dissolved ATP index) coincided with the extent of COD removal. In laboratory experiments, the dissolved ATP index was monitored in reactor samples following a variety of stresses applied to the microorganisms. These included pH shock, temperature shock, chlorination, DO deprivation, starvation, and nutrient addition. The results of the experiments indicated that monitoring the dissolved ATP index reveals whether the environment for the microorganisms is hostile or favorable. Furthermore, the changes in dissolved ATP index were more sensitive to environmental stress than changes in total ATP. Successful determination of dissolved ATP index requires an efficient ATP releasing agent and a dissolved ATP stabilizing buffer. Because the determination of dissolved ATP index can be achieved with less than 2 minutes of labour, it can be easily integrated into a routine analytical monitoring program.

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Study on Cell Agglomeration in Mixed Acidogenic and Mixed Methanogenic Cultures at Different Loading and Mixing Conditions

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Cell agglomeration is a very important property for retaining high cell density in bioreactors dealing with slow growing cultures, especially in the case of methanogenic as well as acidogenic bioreactors for biological wastewater treatment. In order to retain high cell density inside wastewater treatment bioreactors numerous methods have been studied and developed. Unfortunately, most of the present methods have some critical drawbacks, which restrict their wide or universal application. The present study has been done in order to get much relevant information regarding retaining high cell density in acidogenic and methanogenic bioreactors for a wide range of volumetric loading in terms of organic substrate per unit time. Also, different mixing conditions were studied in order to find the effect on the cell agglomeration. In this study, glucose was taken as the organic substrate with some inorganic salts. The acidogenic culture was found to be much easier at granulation, which is a well-known fact. Interestingly, in the present study the granulation was studied for wide range of loading and mixing conditions, e.g., 4 to 175 kg COD m⁻³d⁻¹ and linear velocity in the range of 0.6 to 6.0 mh⁻¹. Also, the granules and cell agglomerates were subjected to shock loadings in order to get some idea about dealing with the practical problems associated with methanogenic bioreactors for wastewater treatment. The simple as well as SEM images of the cell agglomerates suggested the dominance of particular types of cultures among the mixed consortium of anaerobes containing acidogens as well as methanogens. In the present work, Ca⁺⁺ ions were also introduced in the system to observe the effect on cell agglomeration. Both of the acidogenic and methanogenic were found to be almost unaffected by a concentration level of Ca⁺⁺ ions up to 0.1 g L⁻¹, in terms of CaCl₂. The morphology of the granules and flocs were also studied with the help of microscopy and density of the cell agglomerates were determined by their terminal settling velocity values. The size of circular shaped granules varied between 1 to 3 mm in diameter while flocs were irregular in shape. The calculated density for the granules was 1.015 g mL⁻¹.

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COMPETING FOR THE PHILIP H. JONES AWARD

Poly(3-Polyhydroxybutyrate) (PHB) Production Using Waste Activated Sludge as a Source of Microorganisms and Wastewater as a Source of Carbon

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Poly(3-Polyhydroxybutyrate) (PHB) is a biodegradable polyester accumulated by many microorganisms under unfavorable growth conditions. However, its widespread applications have been limited by high production costs. In this study, laboratory experiments were conducted to evaluate the production of PHB using waste activated sludge as a source of microorganisms and slaughterhouse wastewater as a source of carbon. The role of the dissolved oxygen (DO) concentration in PHB synthesis was investigated. The results indicated the possibility of storage polymer (i.e., PHB) production coupling of wastewater treatment. By this approach, it can reduce COD load to be treated in wastewater treatment plants, substantially reduce the treatment cost, as well as the sludge production and sludge disposal cost.

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Performance of Overland Flow System for Advanced Treatment of Plant Effluents

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Although various levels of wastewater treatment can be attained by a combination of operation and process units in mechanical plants, problems such as high costs, operation and maintenance difficulties, and need for specialized operators, simple and cost effective methods should be explored.

An overland flow (OF) system is one of the land treatment methods which has advantages such as low construction and operation costs, easy operation, low detention time, and low energy requirements. The main objective of this study was a performance evaluation of an OF system for the advanced treatment of sanitary and industrial effluents.

In this study, three experimental pilot plants, 4.5×40 metres for each, were constructed at the Isfahan Wastewater Treatment Plant. Each pilot was assigned for a specific effluent and all were simultaneously operated for a period of six months. Performance of these pilots for treatment of primary effluent, activated sludge secondary effluent and lagoon effluent of textile wastewater at loading rates of 0.15, 0.25, and $0.35 \text{ m}^3/\text{m.h}$ was investigated.

The results show that mean removal efficiencies of TBOD₅, TCOD, TSS, TN, TP and turbidity in the loading rate range of 0.15 to $0.35 \text{ m}^3/\text{m.h}$ were 74.5, 54.9, 66.3, 39.4, 36.0, and 67.9% for primary effluent; 53.0, 53.0, 66.5, 44.5, 40.3, and 50.4% for activated sludge secondary effluent; 65.7, 58.8, 70.3, 41.8, 41.2, and 54.9% for lagoon effluent of textile wastewater, respectively. Therefore the removal efficiencies of measured parameters were mostly higher than 50% for all types of effluent. Increasing loading rate causes reduction of removal efficiencies for all measured parameters. Besides, a good performance in reducing organic load for effluents with low ratio of BOD to COD indicates that in an OF system the non-biological processes are quite effective. Overall, it can be concluded that an OF system as an advanced treatment has the ability to meet standard effluent discharge permit limits.

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New Treatment Scheme for Municipal Landfill Leachates

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The main objective of this work was to develop a technology that would provide a cost-effective on-site treatment of the leachate generated by a municipal landfill to allow its discharge in a municipal sewer. Target parameters of the treatment were:

- Total Kjeldahl nitrogen (TKN);
- Total suspended solids (TSS);
- Carbonaceous biochemical oxygen demand (CBOD);
- Inorganic contaminants: hydrogen sulfide, boron, chloride, barium; and
- Volatile organic compounds: m/p-xylene, toluene.

A concept of the treatment train was developed that incorporated the following main steps:

- Solar oxidation for the destruction of volatile organic compounds;
- Enhanced membrane filtration for the removal of inorganic contaminants, TSS, CBOD, and a portion of TKN (non-ammonia fraction); and
- Steam stripping for the removal of TKN (mainly, the ammonia fraction of TKN).

Solar oxidation bench tests revealed that the process could effectively reduce the level of m/p-xylene and toluene and bring it into compliance with sewer discharge limits. Enhanced membrane filtration was very effective in removing the inorganic contaminants, along with TSS, CBOD, and a portion of TKN. The membrane retention of boron should be particularly mentioned, as its removal from aqueous streams is usually a challenging task, due to specific chemical properties of boron. This work involved the use of selected nanofiltration membranes at elevated pH levels. Steam stripping showed an effective removal of ammonia.

Results of the bench-scale study were used to design and build a pilot-scale system. The system contained a solar oxidation unit, a membrane filtration unit, a steam stripping unit, and other mechanical and electrical components. The system was operated at a landfill in Ottawa in summer 2001. Results of the pilot-scale demonstration showed that the process could work under varying conditions while achieving the objectives of treatment.

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Use of the Biosor™ Process to Treat Effluents from the Agri-Food Industry

Case Study: Wastewater from a Poultry Slaughtering Plant

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Since the early 1990s, the Centre de recherche industrielle du Québec (CRIQ) has been working on developing and optimizing its organic-support biofiltration technology, called BIOSOR™, designed to treat highly polluted effluents from the agricultural, agri-food, industrial and municipal sectors. BIOSOR™ is a simultaneous air/water treatment system, whereby liquid and gaseous effluents filter through an organic support (a blend of peat, wood chips, bark, and so forth). As a treatment agent, the organic support acts in two ways; as a natural resin able to fix several types of pollutants (MO, TSS, nitrogen, phosphorous, etc.) and/or as a medium where different microorganisms degrade the substances that have been retained.

Work on the process at the demonstration and scaling stages has been undertaken to treat highly polluted effluents from a poultry slaughtering plant. The system, in place since July 1999, has made it possible to treat 300 m³/d of industrial wastewater and sewage. The discharge criteria at this facility were set to enable ultimate discharge of the treated effluent into the natural environment, a first such target for this process.

Following pre-treatment (screw separator, primary degreasing, septic tanks), the wastewater generated by the factory flows, through the force of gravity, to a hydraulic balancing tank of 200 m³ and then undergoes separation procedures (physical and chemical treatment). Once pre-treated, the wastewater flows into two BIOSOR™ biofilters of 750 m³ each, where the main pollution removal work is accomplished. To treat the wastewater so it can be discharged into the river, a second polishing stage is carried out with another BIOSOR™ biofilter of 750 m³.

To evaluate the pollutant removal performances, usually on a monthly basis for 1200 days of operation, water was taken at the inlet, pre-treatment outlet and system outlet for an analysis of the main environmental parameters. With over 98% reduction of the BOD₅, TSS and O&G, the BIOSOR™ system consistently reached discharge targets. Moreover, the system also made it possible to substantially reduce COD, TKN levels and coliforms.

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In situ Remediation of Hexavalent Chromium with Pyrite Fines in Simulated Field Conditions

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This work has demonstrated the in situ remediation of Cr(VI) in soil and water using pyrite fines at the bench scale under simulated field conditions. The efficiency of the process has been investigated and found satisfactory in converting Cr(VI) into Cr(III) in soil and water matrices. The performance of the process has been monitored by an in-house chromium speciation methodology based on high performance liquid chromatography – diode array detection (HPLC-DAD) and by an outside, accredited laboratory. The results of both laboratories have confirmed the efficacy of pyrite fines in mineralizing Cr(VI) to Cr(III). The process has been further investigated on real Cr waste generated from the project and other waste streams at the facility and found acceptable. More than 100 litres of Cr(VI) waste have been remediated to the Ottawa municipality sewer discharge limit.

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Wet-Weather Flow Pollution Control

Chair: JIRI MARSALEK

Stormwater Control in a Flow Balancing and Wetland Treatment Facility

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A stormwater flow balancing and wetland treatment facility has been built on the shore of Lake Ontario in the City of Toronto as one strategy for enhancing the quality of urban runoff and the receiving water. The design was based on the original Dunkers Flow Balancing System, developed in Sweden by Karl Dunkers. The facility includes a forebay and three series-connected cells designed to retain stormwater. As stormwater enters the facility during a rainfall event, the contents of the existing cells are displaced, flowing into Lake Ontario from the last, downstream cell. Retained runoff is pumped from the first storage cell, through a fourth cell and a wetland (operating in parallel with the series-connected cells), before being released to the lake. The volume pumped out of the storage cells is replaced by lake water that is pumped into the downstream storage cell. As in the original flow balancing concept, this facility employs pontoons and suspended curtains to separate some of the cells. The curtains separating the storage cells have openings designed to promote plug flow conditions, while solid curtains were intended to prevent flow between adjacent cells operating in parallel.

The stormwater control facility—the first of its kind in Canada—was funded by federal, provincial and municipal governments, as part of a water quality enhancement strategy for the Toronto waterfront. It is a unique adaptation of the original concept, in that treatment takes place within the facility rather than in a land-based treatment plant. The facility was approved for demonstration purposes, and an extensive monitoring program was developed for assessment of its performance. This paper summarizes the results of three seasons of flow and water quality measurement, ending in the fall of 2002. Data analysis will be substantially complete by the time of the Symposium.

Data analysis completed to date has shown that the effluent quality is good, meeting surface water quality objectives in many respects. In the first operating season, the average load-based removal efficiency for total suspended solids (TSS) was 74%; total phosphorus was reduced by 72%. Particle size analysis has shown that appreciable separation of the coarser suspended material occurs within the forebay and first storage cell; further separation takes place in all of the downstream locations. The hydraulic behaviour of the flow balancing and wetland system is quite complex. In addition to retaining the runoff, the storage cells provide some flow attenuation and extended detention storage as in a conventional stormwater pond. Dye tests have been undertaken to observe flow patterns and to determine residence times. Some of the results of these tests have shown that the hydraulic behaviour of the system can vary appreciably from idealized plug-flow conditions.

The paper will summarize both the hydraulic and water quality characteristics of the facility. Discussions will include possible modifications to the system and implications for future applications.

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Pilot-Scale Investigations of High-Rate Stormwater Treatment

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The City of Toronto, National Water Research Institute (Environment Canada) and the Ministry of the Environment (MOE) have been operating a demonstration project on high-rate treatment of stormwater by chemically aided settling, which holds a promise of cost-effective mitigation of stormwater pollution. The main objectives of this project are to evaluate innovative treatment of stormwater and thereby support the implementation of the City of Toronto Wet-Weather Flow Management Master Plan and ultimately the delisting of the Toronto Waterfront Area of Concern.

The demonstration pilot plant receives stormwater runoff from a storm sewer which drains into Lake Ontario at 23rd Street in Etobicoke, in the City of Toronto. This sewer drains an area of 298 ha, with industrial/commercial (185 ha) and residential (113 ha) land use. The site hosts a pilot-scale cross-flow plate clarifier and a trailer with automated process control equipment and automatic samplers. Stormwater is fed into the plate clarifier via a submersible pump located in the storm sewer. Clarifier float and underflow sludge, which were sampled manually at the end of the events, were discharged to an adjacent sanitary sewer.

The focus of the study was to evaluate the removal of suspended solids and total phosphorus by polymer-aided settling, under controlled experimental conditions. Three types of experiments were conducted in the plate clarifier: (a) tests with varying dosages of a cationic polymer flocculant, (b) reference tests without polymer, and (c) tests of plain settling without clarifier plates. In response to concerns about potential toxicity of polymer treated effluents, acute toxicity tests were performed on both the pilot plant influent and the treated effluent. Composite samples for *E. coli* enumeration were also collected.

A preliminary analysis of the 2001 and 2002 data shows that the plate clarifier with a 4-mg/L polymer dosage and a total vessel surface load of 15 m/h, on average removed 85% of TSS and 31% of total phosphorus. Microtox test results showed only potential toxicity of the raw stormwater in 12 of the 24 events sampled. All other events were non-toxic and no change in the toxicity was noted for treated effluents. The rainbow trout tests showed almost 100% survival in the raw stormwater in 17 of 19 cases. One sample of untreated stormwater showed slight toxicity, which was reduced by the treatment, and only one sample showed high mortality for both the untreated and treated stormwater.

Finally, process improvements and implications for full-scale application are also presented.

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Spill Management in the Toronto AOC

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One of the water pollution sources in the Toronto AOC is spills. Between 1998 and 2000, there were 2475 oil spills (estimated 830,600 L) and 1584 chemical spills (estimated 1,125,000 L) in Toronto, Richmond Hill, Markham, and Vaughan. Spills affect air, water, and soil and their associated terrestrial and aquatic species. Recognizing the Toronto AOC's restoration targets and priorities, Environment Canada's Great Lakes Sustainability Fund (GLSF), the Toronto and Region Conservation Authority (TRCA), the City of Toronto, the Town of Richmond Hill, and the Ministry of Environment and Energy's Spills Action Centre (SAC) sponsored a study to evaluate spill characteristics and management options for southern York Region and the City of Toronto. The specific objectives of this study are to:

- Review spill legislation
- Compile a spill database
- Analyze spill event characteristics
- Evaluate preventive and control options for municipalities

Based on the findings of the study, the following recommendations are made.

1. The spill reporting and recording system can be further improved by compiling detailed and consistent reports. For instance, spill event volumes should be reported in consistent units and detailed description of cause and reason should be given. Additionally, spill characteristics such as locations, road types, and occurrence of rainfall should be reported as this information will allow the development of sizing criteria for spill control devices. To facilitate spatial analysis of spill characteristics, addresses of spills should be geo-coded by inspectors using Global Position System.
2. Public education of spills should be part of spill management planning by all levels of government. This will improve public awareness of spills and assist the reporting of spills.
3. As human error and equipment related failure are the primary reasons of spills, spill-prone industries should emphasize preventive maintenance and improved employee training.
4. Municipalities can take a lead role in spill prevention. By establishing a municipal sewer use by-law, a municipality can require industries to prepare pollution prevention plans as well as regulate the discharge of toxic chemicals to sewers.
5. A comprehensive spill control strategy should be developed for each spill-prone watershed. Both on-site and off-site facilities should be considered for spill control. On-site oil/water separators should be installed in spill-prone commercial and industrial facilities. At the downstream end of a spill-prone watershed, either a stormwater pond retrofitted for spill containment or an outfall oil interceptor should be used. This strategy should be integrated with land use approval and municipal capital programs.
6. Stormwater management criteria for spill-prone commercial and industrial sites should include a spill control volume that reflects the statistical properties of spill event volume at these facilities.
7. Stormwater ponds which have been identified to receive spills should be investigated further for retrofit potentials.

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Refinement of Hydraulic Operation of a Complex CSO Storage Facility by Numerical and Physical Modelling

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The performance of a combined sewer overflow (CSO) storage facility in North Toronto was investigated by numerical and physical (hydraulic) modelling. Towards this end, a computational fluid dynamic (CFD) multiphase 3-D numerical model, PHOENICS, was set up for, and used in, these investigations. The main study objectives were to: (a) assess the feasibility of increasing the hydraulic loading of the CSO facility without bypass, and (b) establish numerical and physical models of the facility for future work. The numerical model was validated and verified using results from a hydraulic scale model (1:11.6). The results obtained show that the CFD model can simulate hydraulic conditions in the facility reasonably well, as it accurately reproduced the filling rate, water levels at various locations and flow velocities in feed pipes. It was also capable of accurately simulating overflows from the inflow channel, which reduce the performance of this facility in controlling wet-weather pollution. Numerical simulations identified some hydraulic problems in the outflow channel (excessive local head losses in sharp bends) and served for verifying structural solutions to these problems. The analysis of the facility showed that with respect to passage of flows, the facility is a complex, highly non-linear hydraulic system. With a few structural changes examined by numerical simulation, the maximum inflow rate of the CSO storage facility would be increased by up to 31%.

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Coagulant Survey for Chemically Enhanced Settling of CSOs

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Chemically enhanced settling is one option for high-rate combined sewer overflow (CSO) treatment systems that can be operated intermittently. However, CSO wastewaters tend to be highly variable in composition (both between events and during individual overflow events), presenting a challenge to effective treatment. This study evaluated the robustness of various coagulants, flocculants and coagulant combinations in terms of their ability to bring about efficient contaminant removal under variable raw wastewater composition. Jar tests on a simulated CSO wastewater containing dissolved organic carbon (DOC) and variable concentrations of suspended solids (SS) were used to evaluate the efficiency of various inorganic salt and organic polyelectrolyte products.

At a constant DOC concentration, the inorganic coagulants tested were seen to be relatively insensitive to the concentration of SS initially present in the simulated CSO wastewater sample, with excellent DOC removal occurring concurrently with SS removal. However, water pH was lowered by the addition of the inorganic coagulants, and restabilization of the contaminants was observed at high coagulant dosages. Two organic polyelectrolyte flocculants displayed gradual removal of SS with increased dosage, but very poor removal of DOC at all SS concentrations. On the other hand, an organic polyelectrolyte coagulant achieved excellent SS removals and good DOC reduction, and both were relatively independent of initial SS concentration. Unfortunately, the high cost of the polyelectrolyte and high dosages required could limit the practicality of using this coagulant.

Combinations of alum and organic polyelectrolytes were also investigated. Alum with a cationic flocculant displayed very similar behaviour to alum alone in terms of both SS and DOC removal. When an anionic flocculant was used in conjunction with alum, SS removal was achieved at a slightly lower dosage than that required by alum alone, but there was little effect on DOC removal.

The results indicate that adequate characterization of wastewaters is valuable for successful treatment using chemically enhanced settling. As well, contaminant removals should be well defined for the entire process. Although choice of a robust chemical addition scheme is critical for effective treatment of highly variable CSO wastewaters, no coagulant is applicable universally, and both the benefits and drawbacks associated with each coagulant or flocculant should be taken into account.

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Development of a Numerical Simulation Model for High-Rate Retention Treatment Basins used in CSO Applications

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A simulation model has been developed for high-rate retention treatment basins (RTBs) used to treat combined sewer overflows (CSOs). The model simulates the dynamic performance of RTBs and can be used to study the impact of loading conditions, flow control procedures, and total suspended solids (TSS) settleability on treatment performance.

The RTB model contains a hydraulic routing and storage component and a settleability component. The hydraulic component of the model consists of algorithms to achieve volumetric and mass balances. The settleability component consists of an expression that predicts the removal efficiency achieved in the RTB, given the influent TSS concentration and the surface overflow rate (SOR). The settleability model was developed using data from a pilot-scale retention treatment basin in the City of Windsor, Ontario. The model was calibrated using data from tests employing high doses of cationic polymer as the sole coagulant.

For the purpose of process design, the simulation should be run using flow and TSS time-series data from a “typical CSO year” (April to October). Ideally, the data should be actual flow and TSS measurements from the site where the RTB is to be constructed. Because such data are seldom available, a modelling approach was used to simulate appropriate loading conditions. The TSS series was developed using a dynamic-stochastic model that relates the TSS to flow. The model was identified using an influent flow and TSS dataset from a wastewater treatment plant in the same sewershed as the proposed RTB. The dynamic-stochastic model has a second-order autoregressive noise model and a second-order plus dead time transfer function model between flow and TSS.

The calibrated RTB simulation model and the generated load data were used to conduct year-long simulations of the proposed Windsor RTB. Studies were conducted to determine the tank size necessary to treat the Windsor CSOs according to provincial CSO control guidelines. The sensitivity of the RTB simulation model was examined by studying the impact of reduced settleability and different levels of noise in the TSS model. It was found that the model is most sensitive to the settleability model parameters. The settleability and time-series models developed in this project provide a foundation for further modelling and simulation studies of high-rate RTBs.

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Drinking Water Quality and Treatment

Chair: SUSAN B. WATSON

Inshore Areas: A Primary Source of Taste and Odour in the Upper Saint Lawrence River

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Taste and odour (T/O) is an annual fall event affecting the upper St. Lawrence River (SLR), caused by geosmin (G), and particularly 2-methylisoborneol (MIB). These compounds impart musty, earthy flavours to the water and reduce its potability. Initial wide-scale surveys in eastern Lake Ontario and the SLR indicated G-MIB were produced mainly in the river. In 2000, we began a study to identify the biological origin(s) and underlying causes of these events. The SLR has extensive macrophyte beds and inshore areas for periphyton production as potential odour sources. Over three years, we have sampled sites between Kingston and Cornwall for G-MIB, water chemistry, light, temperature and biota. Macrophytes (or their biofilms) yielded significant geosmin, but no MIB. Comparison of *Valisnaria* and *Myriophyllum* from beds at two sites showed significant differences in geosmin yields between macrophyte species and between sites, which were not clearly linked with ambient nutrients. Periphyton from rocks also showed significant yields of cell-bound G-MIB, up to 100x the water levels. There was significant spatial variability between and within sites, and intriguing temporal patterns, again with little relationship to nutrients or other measured parameters. Periphyton showed highest G-MIB below Cornwall in August, with MIB predominant but decreasing through November; geosmin showed little change. Several periphytic cyanobacteria were identified as potential odour sources. Their recent onset in the last decade may be indicative of profound changes in the river ecosystem.

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Cyanobacteria and Drinking Water Odour: Within- and Among-Species Differences Re-examined, Using Systematic Taxonomic, Experimental and Analytical Protocols

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Drinking water taste and odour (T/O) traditionally is associated with culturally eutrophicated surface waters and musty/earthy/putrid volatile organic compounds (VOCs) produced by Cyanobacteria. Collectively, these represent a highly diverse group with a large number of morphological species, and without doubt are the most-studied taxa in this area of research. But despite this diversity, relatively few species actually have been identified as sources of surface water T/O, and fewer still subsequently isolated and confirmed as odour sources. Furthermore, existing studies suggest that VOC production is not a robust, species-specific trait, and thus their VOC production needs to be re-confirmed for each event. Clearly, this confounds the development of predictive early warning systems, essential for proactive treatment and management.

We propose that much of this ambiguity may stem from several key, unresolved issues: i) species misidentification, often because of general lack of expertise in the face of continually evolving taxonomic classification; ii) variation in species' morphology and VOC production with life-cycle and key environmental factors, which in most cases remains undefined; iii) in vitro studies based on culture collection strains, whose original identification is unconfirmed, or which have evolved fundamental physiological or morphological changes over long-term culture; iv) the wide range of (in vitro) VOC production with some species reportedly far more prolific than others, which may stem in part from differences in culture and analytical protocols; v) a historical tendency to focus on planktonic biota, with the odour potential of periphyton only recognized recently.

In an ongoing study, we are using a systematic approach to resolve some of these issues. This approach investigates the range of variability in morphology and odour-production associated with different strains of individual Cyanobacteria species that have been previously linked with odour production. Strains of each species were isolated from field samples, or obtained from private and commercial collections, and their i) identification confirmed from morphological taxonomic classification using light and electron microscopy; ii) VOC production and morphological variation characterized, both in vivo (based on literature and unpublished data) and in vitro, under well-defined culture conditions where key parameters are varied over levels representative of natural ranges (e.g., light, temperature, nutrients); iii) their ecology and biodistribution described, where available. This paper will present some of the results and implications from this study, focusing on two isolates of *Anabaena lemmermanii*, which show marked differences in odour production and morphology both between strains and under different environmental conditions.

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Removal of Earthy/Musty Odour Compounds from Drinking Water by Biological Filtration

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The presence of compounds that can impart tastes and odours, such as the earthy/musty odours produced by geosmin (trans-1, 10-dimethyl-trans-9-decalol) and MIB (2-methylisoborneol) can sometimes diminish the quality of drinking water. Many water treatment utilities in North America reported intense earthy/musty taste and odour events lasting approximately one week. Utilities, therefore, may spend a significant part of their budget on taste and odour control. While treatment technologies exist (e.g., powdered activated carbon, oxidation using chlorine, chloramines, or even ozone), they can be expensive and have been shown to be ineffective in removing these compounds to below their odour threshold concentration levels. Effective treatment, however, can potentially be provided by ozonation followed by biological filtration.

This research is evaluating the efficiency of biological treatment in removing or minimizing these odour compounds. The overall goal is to improve our understanding of the factors affecting the removal of geosmin and MIB by this process, so it can be optimized. The specific objectives identified to meet this goal are:

1. to evaluate the role of biofiltration media type in supporting biofilms capable of removing geosmin and MIB;
2. to evaluate the major design and operational factors, such as temperature and flow rate, which may influence the overall removal of geosmin and MIB throughout the treatment process; and
3. to determine the kinetic parameters for biodegradation of geosmin and MIB under realistic drinking water conditions.

Bench-scale experiments were conducted using four parallel filter columns in which two columns contained exhausted granular activated carbon (GAC) media and sand, and two columns contained fresh anthracite and sand. Source water consisted of dechlorinated tap water to which geosmin and MIB were added, as well as a cocktail of easily biodegradable organic matter (i.e., typical ozonation by-products), in order to simulate water that had been subjected to ozonation prior to filtration. In order to investigate the impact of temperature on the biological removal of geosmin and MIB, two columns were heated to 20°C (i.e., one column containing exhausted GAC/sand, and one containing anthracite/sand), and two columns were cooled to 8°C (i.e., one column containing exhausted GAC/sand, and one containing anthracite/sand). To assess the impact of the transient nature of odour episodes on biofilter performance in terms of geosmin and MIB removal, these experiments simulated the development of an odour event at various rates, including an instantaneous maximum probable event.

These bench-scale experiments employ a 2³ factorial design in two blocks of four runs each. The design will allow for the analysis of the significant factor(s) and potential two-factor interaction(s) on biofilter performance. The system variables include water temperature, geosmin and MIB influent concentrations, and filter media. Data analysis of blocks 1 and 2 are in progress and the results will be presented. Preliminary analysis of the data shows that percent removals of both geosmin and MIB are significantly higher in the column containing the GAC media and run at the higher temperature. Percent removals in these columns range between 56 to 76% for geosmin and between 23 to 58% for MIB.

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COMPETING FOR THE PHILIP H. JONES AWARD

N-Nitrosodimethylamine Formation from Amine-Based Polyelectrolytes Used in Drinking Water Treatment

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N-nitrosodimethylamine (NDMA) is classified as a probable carcinogen by the U.S. EPA. Based on the U.S. EPA's 5×10^6 risk factor the Ontario Water Quality Standard (OWQS) has been set to 9 ng/L. Interest in NDMA has recently risen due to the discovery that NDMA could form during water treatment. Previous work has shown that amines in the polymers polydimethylammonium chloride (polyDADMAC) and epichlorohydrin-dimethylamine (Epi-DMA), both used in water treatment as primary coagulants, could act as precursors for NDMA in the presence of nitrite and chlorine. It was concluded that the nature of the amine structure in the polymer determined whether the polymer would act as a precursor.

To verify this conclusion three other amine-base polymers have been tested: polyethylenimine, polyethylene polyamine (or polyalkyleneamine), and Epi-DMA with ethylenediamine. Testing consisted of bench-scale simulations of the coagulation/flocculation/sedimentation process, varying nitrite, polymer, and chlorine dose according to a 2^3 factorial design. The experimental procedure can be summarized as follows: nitrite, polymer, alum, and chlorine were added to 1 L of tap water with an adjusted pH of 7. Coagulation/flocculation/sedimentation was simulated using a paddle stir apparatus. The final treated water product was then measured for nitrite concentrations, turbidity, free and total chlorine residual, pH, and NDMA concentrations. NDMA levels were measured using solid-phase extraction, which employs Amborsorb 572 as the carbonaceous bead and dichlormethane as a solvent. The extraction was run on a Hewlett Packard low resolution 5890 II Gas Chromatograph/5971 Mass Selective detector. The minimum detection level was determined to be 3 ng/L.

Polyethylenimine produced only two samples with NDMA yields above the minimum detection limit; polyethylene polyamine produced detectable NDMA yields but generally below the OWQS; and Epi-DMA with ethylenediamine produced high concentrations of NDMA. Discussion and comparisons of the results shall be included in the presentation.

In addition, a complication that is often mentioned in other studies on NDMA formation from amine-based polymers is the uncertainty of the effect of polymer stock age. To address this uncertainty, coagulation/flocculation/sedimentation simulations were run using polyDADMAC and Epi-DMA stocks of different ages. The results are currently being analyzed. Should prepared polymer stock age influence NDMA yields, this would offer troubled utilities an additional means to control NDMA concentrations at their plants.

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UV Inactivation of Floc-Associated MS-2 Coliphage

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The ability of ultraviolet (UV) light to disinfect alum floc-associated MS-2 coliphage was evaluated. Particle-associated organisms receive reduced UV doses and therefore can remain viable post-disinfection. Previous studies of wastewaters have shown that particles greater than 10 μm are capable of enmeshing coliform bacteria, thereby protecting them from ultraviolet disinfection. However, viruses are two orders of magnitude smaller than coliform bacteria, and it may be hypothesized that particles smaller than 10 μm , such as clay particles (<2 μm), would have the ability to shield viruses from UV.

Milli-Q[®] water was spiked with MS-2 coliphage, kaolin clay particles, and alum. A jar test apparatus was used to coagulate particles and organisms together and cause floc growth. Initial MS-2 titers were approximately 10^5 plaque-forming units (PFU)/mL. MS-2 coliphage (~25 nm diameter) is representative of the size and structure of human enteroviruses. Kaolin clay was used as a surrogate for inorganic colloidal particles found in water. Kaolin was dosed at a concentration of 12.5 mg/L and alum was added at 30 mg/L, to produce a turbidity of approximately 10 NTU. Turbidities more representative of post-filter waters (<1 NTU) will also be presented.

UV exposures were conducted using a low pressure collimated beam. The inactivation of MS-2 coliphage for the clay suspensions was compared to that of disperse, unassociated MS-2 in a clear phosphate buffer solution, which was used as a control. Particle size distributions of the jar test supernatants were measured using a Beckman-Coulter Multisizer. The floc exhibited mean particle diameters of approximately 2 μm .

Alum floc-associated MS-2 was extracted from surrounding particles by the addition of a 2% beef extract eluent and three minutes of blending at 20,000 rpm, a method that does not affect the viability of MS-2. The inactivation of the alum floc-associated MS-2 population was assessed by conducting this extraction procedure on samples collected both pre- and post-UV. Once extracted, MS-2 coliphage were enumerated using a standard overlay agar method.

The average UV fluence throughout the fluid in all samples was 40 mJ/cm^2 . Previous research had shown that 40 mJ/cm^2 is capable of inactivating between 2- and 2.5-log MS-2 in samples where particles are absent. Inactivation of alum floc-associated MS-2 was found to be consistently around 1.5-log, that is 1-log less than was observed in the clear samples.

The floc-associated fraction of the total MS-2 population was greater post-UV than pre-UV due to the disperse population being disinfected. Also, the log inactivation of the disperse MS-2 fraction was higher than that of the floc-associated MS-2 fraction and was comparable to the inactivations observed in the clear control samples.

The results of this bench-scale research suggest that small floc particles, representative of inorganic colloidal particles that may pass through treatment, are able to enmesh and protect MS-2 coliphage, and hence viruses, from UV irradiation. These results supplement previous research which demonstrated that viruses are protected from chemical disinfection (chlorine, chloramines) by inorganic colloidal particles.

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Watershed and Water: Quality Assessment

Chair: ALICE DOVE

Facilitating Climate Change Impacts and Adaptation Research for Canadian Water Resources

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Recent climate variations experienced throughout Canada (such as the recent severe drought in the Prairies, melting of permafrost in the McKenzie Basin, flooding in Saguenay, ice storm of 1998), have impacted ecological, social and economic systems. The hydrological cycle is responsible for governing precipitation rates, and the consequent replenishment of surface and ground water, and ultimately sustaining all forms of life. The impacts of global warming on the hydrological cycle, and subsequently on water resources will be widespread and potentially severe. To better understand what the effects of climate change on Canadian water resources will be, a network known as C-CIARN (Canadian Climate Impacts and Adaptation Research Network) was set up by the federal government, universities, provincial governments and other partner institutions to disseminate knowledge on the impacts of climate change and potential adaptation strategies. The C-CIARN network is comprised of six regions and seven sectors, one of which is the Water Resources Sector.

The Water Resources Sector of C-CIARN was set up in January 2002, and is hosted by the Brace Centre for Water Resources Management, at McGill University. The mission is to build a network composed of researchers and stakeholders, facilitate research and help to provide voice and visibility to climate change impacts and adaptation issues. C-CIARN Water Resources works at identifying research priorities that address impact and adaptation uncertainties of importance to stakeholders. The Sector shares relevant information among the research and stakeholder community and helps increase the visibility and understanding of climate change impacts and adaptation issues among policy makers and the public in order to facilitate impacts and adaptation measures. The Sector also identifies funding opportunities to its members.

An example of the type of activity undertaken by the Sector is organizing and hosting a major workshop. In September 2002, the C-CIARN Water Resources Sector convened a workshop on "Water Resources at Risk due to Climate Change," which identified climate change impacts and adaptations relevant to specific sectors of water resources (agriculture, hydro power and energy, shipping and navigation, communities, ecosystems and environment). Over 70 experts from across Canada participated in prioritizing research needs and identified knowledge gaps related to the impacts and adaptations of climate change and water resources. A report ensued which was widely distributed, and was made available to funding agencies to serve as a guide to tailor their call for proposals in the area of water resources.

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Application of the CCME CWQI for the Communication of Drinking Water Quality Data in Newfoundland and Labrador

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The Government of Newfoundland and Labrador is committed to providing clean and safe drinking water to the public by implementing a Multi-Barrier Strategic Action Plan (MBSAP) for drinking water safety. This plan is based on the principles of the multi-barrier approach. Monitoring and reporting of drinking water quality data is an important element of the MBSAP.

Currently, drinking water quality monitoring results are communicated to communities throughout Newfoundland and Labrador on a quarterly basis along with an annual report. This information is also made available on the Department of Environment Web page. From this dissemination of information, it has been found that numerous communities have difficulties interpreting the analytical results. Thus, it was necessary to find and implement a communications tool that could simplify the interpretation of drinking water quality monitoring results without challenging the integrity of the water quality data. The Canadian Water Quality Index (CWQI), developed by a sub-committee established under the Canadian Council of Ministers of the Environment (CCME) Water Quality Task Group, was identified as a potential tool to address this issue.

The CWQI was developed as a means to summarize large amounts of water quality data into simple terms (e.g., good, poor, etc.) for reporting to the decision makers and the public in a consistent manner. An index allows the user to represent a variety of measurements of numerous variables in a single number and corresponding ranking category. This simplifies and facilitates the communication of results.

The Newfoundland and Labrador Department of Environment carried out extensive testing of the CWQI on the provincial drinking water quality data by applying the CWQI on selected data sets. The resulting CWQI rankings were compared against expert opinion on each particular water body. The results indicated that the CWQI would be an appropriate tool for the interpretation and dissemination of drinking water quality data. However, based on the comparison, a need was identified to modify the existing CCME CWQI categorization scheme. A need was also identified to develop data selection and reporting protocols to maintain the provincial data reporting standards and requirements. The CWQI is being incorporated into the provincial automated quarterly drinking water reporting system.

This paper describes the testing methodology; the rationale for modifying the existing CCME CWQI categorization scheme; the development of data processing and selection protocols; and the implementation of an automated CWQI calculator in the provincial drinking water quality Microsoft Access database. The paper also discusses the challenges encountered in using the CWQI as a communications tool for drinking water quality data especially with respect to identification of contaminants and incorporation of bacteriological data. Also described are further areas of research that have been identified as a result of this work.

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Water Quality Strategy for the Credit River Watershed

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The Credit Valley Conservation (CVC) is responsible for the management of water resources within the Credit River watershed, which is approximately 1000 km² in area and lies just west of Toronto. The watershed is under significant pressure from urban development, as well as agricultural uses and aggregate extraction activities. Earlier work identified the need for a Water Quality Strategy to achieve a watershed-wide approach to addressing larger scale issues, such as cumulative impacts, and to identify and develop protection strategies.

The original work plan consisted of ten steps, which can be condensed to six major tasks:

1. Background review to identify issues and data gaps;
2. Development of a framework for setting water quality objectives;
3. Selection and development of an appropriate assessment tool;
4. Testing of future scenarios and evaluating potential impacts within Objective Framework;
5. Addressing conflicts between potential impacts and objectives; and
6. Preparation of a Water Quality Strategy and transfer information to watershed partners.

It was anticipated that the process would take at least 5 years to complete and that Steps 4 to 6 will be an iterative process. CVC is currently at the end of the second year of this study. To date we have collected and analyzed extensive background data and information. This has included a listing of the issues voiced by the public, various interests groups and agencies. These issues were translated into critical related watershed function(s) and parameters that described those functions were identified. Those parameters that were applicable on a watershed scale were placed on the list of “Parameters of Concern” for the Credit River Watershed. We then developed a framework for setting watershed-wide water quality objectives using a River Zonation concept. River Zones that meet similar criteria are identified based on the Parameters of Concern established for the watershed.

CVC has also determined that our needs for a watershed-scale assessment tool can be met with a sophisticated water quality model, which will enable us to measure our success within the River Zonation framework. HSP-F (Hydrological Simulation Program in Fortran), a dynamic, deterministic water quality model, was selected to enable the evaluation of all eligible Parameters of Concern and to capture the substantial spatial and temporal variability in the Credit River watershed. The hydrological development of the model has been completed and key water quality parameters are currently being set up and tested in the model. The initial impact assessment scenarios include future (2021 and 2051) land use scenarios, servicing options, and climate change.

The paper will introduce the concepts of Parameters of Concern and River Zonation, describe the water quality model selection, development and testing process, and map out the remaining tasks to be completed in the Water Quality Strategy.

This work will be incorporated with other watershed work (water budget, monitoring, subwatershed studies, etc.) and ultimately create the foundation of a water management strategy for the Credit River. This work will form a proactive basis on which to protect and enhance the watershed water resources in light of extensive land use changes facing the watershed.

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Method Development for the Analysis of Waterborne Carbamate, Phenyl Urea, and Organophosphate Pesticides

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A liquid chromatography/electro spray ionization/mass spectrometry-mass spectrometry (LC/ESI/MS-MS) method for the quantitative analysis of three categories of pesticides in aqueous matrix has been developed. Discussed in this presentation are the sample preparation method, LC/MS-MS method, method performance data, and pros and cons of current approach. We'll demonstrate that using solid phase extraction (SPE) technique, one can extract these three groups of pesticides with one single SPE cartridge. Using a reverse phase HPLC separation, soft ionization methods, and multiple reaction monitoring (MRM) MS-MS technique, we can further selectivity and specificity of the analysis to eliminate matrix effects. This reduces background interference (thus, noise); enhances the signal-to-noise ratio (SNR) of the experiment; and allows the application of the same procedure to a multitude of matrices including vegetation and soil matrices. This work demonstrates the feasibility of using a reverse phase HPLC separation and MS-MS detection method for the screening of three very different categories of pesticides with superior SNR. Upon positive identification, quantitative analysis will be carried to obtain the amount of a specific target compound in a given sample. Problems and solutions related to the analysis of certain organophosphates compounds will be discussed.

Selection of Inflow Parameters in the Design of Best Management Practices for the Removal of Suspended Sediments and Oil from Urban Runoff

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Despite its importance for the performance of best management practices (BMPs), the selection of design inflow parameters is not regulated in Ontario. This may lead to inconsistencies in performance and the potential for violations of the criteria. The paper discusses this aspect for two types of pollutants, with further details provided related to oil water separators.

Current design and selection practices for BMPs in Ontario is, in general, deterministic. Regulatory criteria are based on:

- I. Maximum permissible effluent concentrations, such as the Ministry of the Environment (MOE) requirement of a maximum 15 mg/L for oil, the City of Toronto Sewer Use By-law of 15 mg/L for suspended sediments, etc.
- II. Other criteria, such as the ones recommended by the MOE Stormwater Management Practices Planning and Design Manual are based on a percentage removal of the annual total suspended sediment (TSS) load, which varies with the ecological sensitivity of the receiving water body. As an example, for the most sensitive “Level 1” streams, the TSS removal should be not less than 80%.

In order to meet these criteria, designers evaluate the performance of various types of BMPs based on various models described in manuals, other literature or, for oil water separators, on information from the manufacturers. Some of these models consider as a parameter the fall velocity in water of a characteristic sediment particle (or rising velocity of an oil globule). Other factors considered are the mean flow velocity based on a “design discharge” and the geometric characteristics of the BMP.

Application of the deterministic approach seems relatively straightforward and, although there is not always adequate testing for the models, they are generally well documented. The implementation of this approach is further facilitated by recommended tables for direct selection of volume for the sediment trap (m³/ha) or the dimensions of the oil water separator tank given by the manufacturers.

A less defined aspect related to the BMP design is the inflow parameters to be used in the models. Two types of parameters are analyzed based on various monitoring data and the review of some designs:

- I. TSS or oil concentrations in urban runoff for different types of land uses; and
- II. Size distribution of suspended solids or oil globules – to be considered in the fall and rising velocities, respectively, in water.

Ideally, both parameters should be selected based on adequate monitoring under local conditions. However, quite frequently they are selected from literature, which, as shown by the examples, gives a significant potential for a large variation in designs.

The paper discusses the sensitivity of the design characteristics to the input data. Based on experience with monitoring programs and various applications, it is proposed to develop, as a complement to the deterministic approach, recommendations for “design concentrations” to ensure consistency and to avoid the potential for the failure of costly facilities and provides some typical design comparisons to illustrate the need for this concept. It is also considered that, in some situations, it may be necessary to evaluate the risk of criteria violations based on a statistical analysis.

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COMPETING FOR THE PHILIP H. JONES AWARD

Water Quality Evaluation of a Construction Sediment Pond

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Urban construction sites can cause detrimental impacts on fish and fish habitats if erosion and sediment control practices are not properly implemented. Unfortunately, current erosion and sediment control practices have been criticized for providing little protection during wet-weather conditions. Sediment control ponds are often used as a control practice to minimize the impacts of soil erosion and sediment transport. If designed properly, sediment control ponds can be effective in controlling sediment-laden runoff from construction sites where erosion and sediment loads are significantly high. Current sizing criteria of sediment control ponds in Ontario are based on a storage of 125 m³/ha and a detention time of 24 hours in a dry pond setting. Since the release of the Ontario Ministry of the Environment's Stormwater Guidelines in 1994, the Toronto and Region Conservation Authority has adopted the new storage requirements in a wet pond setting for both sediment control during construction and stormwater quality treatment after construction. This research project is monitoring the water quality performance of a sediment control pond designed using the new criteria and will provide data for future modelling investigations of the effectiveness of the new criteria. During the fall of 2002, storm runoff was monitored in and out of the pond, and pollutant removal efficiencies were estimated. Preliminary results indicate that the pond is ineffective in removing certain pollutants. Monitoring will continue through the spring of 2003. Ultimately, this research will enhance our knowledge of runoff sediment characteristics during the construction phase and the effectiveness of sediment ponds.

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Waterborne Pathogens

Chair: SUSAN B. WATSON

Microbial Source Tracking: Antibiotic Resistance Profiling and DNA Fingerprinting of *E. coli* Isolates for Determining Sources of Fecal Pollution

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Many waterborne pathogens are of fecal origin and thus tests for fecal indicator bacteria (e.g., fecal coliforms and *E. coli*) provide a basis for predicting the occurrence of pathogens in water. However, these coliform indicator tests provide little information for determining the likely source of fecal contamination for corrective actions. In order to develop methods to better understand the sources of fecal contamination for beach closures, we have been investigating two microbial source tracking techniques: antibiotic resistance profiling and the DNA fingerprinting technique of rep-PCR (polymerase chain reaction). We are applying these techniques to characterize *E. coli* isolates from beach waters and nearby fecal pollution sources. A preliminary library of over 500 *E. coli* isolates has been obtained from different fecal sources in the Hamilton Harbour area including municipal wastewater effluents and bird feces (e.g., Canada geese, ducks, gulls). The resistance of *E. coli* isolates to various concentrations of 8 different antibiotics was used to develop antibiotic resistance profiles of the isolates from each fecal source. These antibiotic resistance profiles provided an ability to discriminate *E. coli* isolates from different fecal sources. The rep-PCR technique is being applied to these same isolates to determine if it can improve discrimination of fecal sources. The *E. coli* library is being expanded and will be tested for its ability to identify the fecal source of *E. coli* isolates obtained from beach waters in the Hamilton area.

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Microbial Source Tracking Using *Bacteroides–Prevotella* 16S rRNA Gene Targets

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Bacteria such as faecal coliforms, *Escherichia coli* and faecal Streptococci, and bacteriophages have long been used as indicators of faecal pollution of water. However, identifying the specific host species responsible for point and non-point sources of faecal contamination of water has also become an area of great concern. The species source information will help us to design better intervention strategies to limit sources of faecal contamination of water and also provide an assessment of the relative contribution of each of these host species sources to the microbial load in a particular water system. Selected phenotypic and genetic traits of indicator bacteria, such as *E. coli* and faecal streptococci, isolated from the feces of specific host species have been used in “library-based” methods for identifying clusters of host-specific bacterial traits in bacterial populations. Other methods of source tracking of feces rely on host species-specific chemical and microbial signatures unique to the host species. We have recently initiated studies on microbial source tracking in the Oldman River basin in southern Alberta. In these studies, methods for detection of host species-specific segments of the 16S rRNA genes of members of the *Bacteroides–Prevotella* group of anaerobic bacteria have been adopted from the literature and modified for use in species-specific PCR formats. These gene targets have been shown to be useful in PCR assays for differentiating between feces of human and ruminant origin, for example, one PCR primer set we have designed appears to be ruminant-specific. This primer set produced a single 469 bp PCR fragment with DNA extracted from all of 18 bovine and 6 ovine faecal samples and from all of 11 water samples from a feedlot catch basin. However, it did not amplify DNA extracted from 15 municipal sewage samples. In contrast, a human-specific PCR primer set amplified a single 573 bp PCR fragment with DNA from all of 15 sewage samples from 5 local sewage treatment plants but did not amplify the DNA extracted from the ruminant faecal samples mentioned above. Further, neither PCR primer set amplified DNA extracted from porcine feces. These 16S rRNA PCR assays should be useful for discriminating between human and ruminant faecal contamination of waters in the Oldman River Basin and elsewhere. Further studies are planned to help identify faecal contamination of waters in this region from other mammalian and avian host species using *Bacteroides–Prevotella* gene targets in PCR assays as well as library-based and other methods of microbial source tracking.

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Development of a Dual Colour Flow Cytometric Method for the Simultaneous Detection of *Giardia* Cysts and *Cryptosporidium* Oocysts

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We have previously described a flow cytometric method for the detection of *Giardia* cysts, *Cryptosporidium* oocysts, and *Cyclospora* oocysts in various environmental samples and found the method to be faster, more sensitive and objective than immunofluorescence microscopy. Therefore, the development of a dual colour flow cytometric method for the simultaneous enumeration of *Giardia* cysts and *Cryptosporidium* oocysts is of interest for the rapid detection of these parasites. Commercially available *Giardia lamblia* cysts and *Cryptosporidium parvum* oocysts were used to optimize their recoveries by means of sucrose flotation. The specificity of both monoclonal antibodies, anti-*Giardia* FITC and anti-*Cryptosporidium* RPE, was assessed by cross-reactivity testing. The sensitivity of this method in the detection of cysts and oocysts was determined using samples of known concentrations. The flow cytometry analysis was performed using a FASCalibur flow cytometer with CELLQuest ProSoftware. Results demonstrated that flow cytometry can be used for the simultaneous detection of *Giardia* cysts and *Cryptosporidium* oocysts. We are currently applying this methodology to examine beaver faecal samples and seal intestinal contents to determine the prevalence of *Giardia* and *Cryptosporidium* sp.

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Environmental Effects on Drinking Water, Waterborne Pathogens and Human Serological Response, the British Columbia Experience

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Surface water from five communities and groundwater from one community were studied. The environmental effects on the source water of these communities from protected and non-protected watersheds were recorded, waterborne parasites were identified, possible contribution of animals to source water contamination in one protected watershed was assessed and community serological response of residents to the parasite *Cryptosporidium* were compared in outbreak and non-outbreak situations. Retrospective analyses of significant rainfall events in an outbreak and a non-outbreak community were carried out to look for correlations between these events and community serological response to *Cryptosporidium*.

Our studies show that precipitation and other environmental factors and animals in and around the watersheds may impact the microbiological quality of the source water and which appears to influence the serological response of residents in the community. Preliminary comparison analyses appear to show a correlation between significant rainfall events and community serological response.

Our current Canadian Water Network (CWN) study: Establishing an Interdisciplinary Network and the Study of Watershed and Communicable Disease Events, will be completed in three phases. British Columbia, Phase 1, to be completed December 2002; Alberta, Phase 2, in December 2003; and Ontario, Phase 3, in 2004. Environmental factors are among 16 water quality parameters that will be studied and compared.

Data to be used in this presentation were obtained from a previous project sponsored by the University of British Columbia and American Water Works Association Research Foundation and from a current project sponsored by the Canadian Water Network.

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Posters

Sustainable Water Well Initiative:

Evaluation of Electrokinetics to Control Water Well Biofouling

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Water wells are the primary water supply source for most rural residents on the Canadian Prairies. To address the concerns of rural residents who are experiencing declining well yields and water quality deterioration, the Prairie Farm Rehabilitation Administration (PFRA)-Technical Service created the Sustainable Water Well Initiative (SWWI) to provide improved knowledge on the diagnosis, prevention and remediation of groundwater-related problems. To date, SWWI activities have primarily focused on the effects of microbiological activity on groundwater supplies, since the diagnosis and remediation of biological plugging in the water well environment is poorly understood.

A study currently undertaken by PFRA is to evaluate an application of electrokinetics to control biofouling in the water well environment. The concept of using electrokinetics to mitigate the effects of biofouling is not new. Research by others in the biomedical field has shown that a direct current can cause significant changes to the structure of biofilm attached to the surface of an electrode. These changes include significant biofilm shrinkage at the surface of the anode and slight swelling on the surface of the cathode. To further investigate this phenomenon, PFRA constructed a bench model water-well to investigate the effects of a weak electrical field on biofilms. The effect of the electrical field on the biofilms was determined by direct measurement of head losses through an array of piezometers in the test cell, during scheduled pumping tests. Nutrients were added to the test cell to encourage biofilm development. When it became difficult to sustain a range of prescribed pump test rates, the test cell was considered fully biofouled and the biofilms were then exposed to a weak electrical field. Within a two-month period after application of the electrical field, pump test results indicated that drawdown levels in the test cell recovered to within 15 percent of the pre-biofouled levels. These findings suggest that the biofilm shrank in the vicinity of the well screen, causing an increase in permeability.

Field tests on biofouled wells are also underway at two sites. The purpose of the field tests is to determine if the positive laboratory results can be duplicated in the field. At one site, an impressed current system was installed around a 20-year old well that had lost about 80 percent of its original specific capacity. This well was considered severely biofouled, with a mature biofilm replete with mineralization. At this site, pump tests conducted over a seven-month period indicated a 15 percent increase in specific capacity. This result is encouraging, considering that at this experimental stage neither the anode array or electrical field strengths have been optimized. At a second site, field tests are being initiated on wells where the biofilm development and aquifer plugging is expected to be more juvenile, and more likely to represent conditions experienced in the laboratory investigations. Although only in the initial experimentation stages, the potential for utilizing impressed current systems to control biofilm development in the water well environment appears promising.

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Assessing the Impact of Bioremediation of a Tetrachloroethylene-Contaminated Environment on Amphibian Larvae

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Concerns regarding the ecological risks of introducing microorganisms into contaminated aquifers to hasten remediation has prompted the regulation of their use. This study assessed the biosafety of three approaches for the bioremediation of tetrachloroethylene (PCE) using amphibian embryos and larvae as model wetland receptor species. A large-scale model aquifer was constructed, PCE was injected, and three remediation treatments were conducted, bioaugmentation, biostimulation, and natural attenuation. The bioaugmentation treatment involved the addition of a bacterial consortium preadapted for PCE metabolism; in the biostimulation treatment, the indigenous microbial population was stimulated by the addition of methanol and lactate; for the natural attenuation, no addition was made. To ensure that neither the biostimulation nor the bioaugmentation were contributing to the growth of potential pathogens, the presence of two protozoa (*Cryptosporidium* and *Giardia*) and nine bacteria or groups of bacteria were monitored. Embryos and tadpoles of the African clawed frog (*Xenopus laevis*) were exposed acutely (96 h) and chronically (to transformation) to aquifer effluent from each of these remediation treatments and monitored for deformities, growth, and survivorship. Results have shown that African clawed frog embryos were not affected by exposure to aquifer effluents.

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Evaluation of a Science-Based Alternative Management Practice for the Treatment of Farmyard Runoff and Milk House Washwater

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At a medium-sized dairy farm in southern Ontario, a passive subsurface treatment system is being evaluated for the management of a combined source of farmyard runoff and milk house washwater. The system is comprised of three NITREX™ Plus Filters designed to remove nitrate and bacteria and a PHOSPHEX™ Filter designed to attenuate phosphate and bacteria from the waste stream. Treated wastewater leaving the filter series is released through a weeping tile to the regional groundwater system. These technologies are well proven in the area of domestic wastewater treatment and are being used for the first time together to treat agricultural effluent. Early results from this work suggest excellent treatment as an overall elimination of nitrate, phosphate, and bacteria have been observed and were found to be consistent over extended time periods. Currently, work is being done to maximize the efficiency of the system to allow predictions to be made with regards to the technology's sustainability, treatment capacity and overall cost. The site used for this study is one of the PINUE (Partners in Nitrogen Use Efficiency) locations in southwestern Ontario where extensive data collection and nutrient flux monitoring is ongoing. This paper summarizes the preliminary evaluation of this technology and discusses the use of these emerging approaches in managing agricultural wastewater.

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Density Stratification of a Northern Manitoba Lake Induced by Acid Mine Drainage

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An integrated groundwater and surface water study was conducted to evaluate the geochemical evolution of a lake in northern Manitoba, which has been severely impacted by acid mine drainage. A sulfide-rich tailings impoundment adjacent to the impacted lake has undergone over 70 years of sulfide oxidation. Concentrations of sulfide oxidation products are extremely high in the tailings pore water (pH < 1, up to 129,000 mg/L Fe, 280,000 mg/L SO₄, 55,000 mg/L Zn, 5700 mg/L Al, 1620 mg/L Cu, 97 mg/L Cd, 55 mg/L As, and other metals). Surface runoff and groundwater discharging from the tailings flow directly into Camp Lake adjacent to the impoundment. Concentrations of metals and SO₄ in the lake waters are elevated, with maximum concentrations observed in a semi-isolated embayment (8500 mg/L Fe, 20,000 mg/L SO₄, 30 mg/L Zn, and 100 mg/L Al). An abrupt increase in metal and sulfate concentrations at a 2-metre depth in the embayment suggests that higher density metal-laden water is accumulating at depth, preventing normal mixing processes. The mine-impacted water from Camp Lake flows into Kississing Lake, which is the location of a commercial fishery and the community of Cold Lake. Elevated concentrations of Fe, SO₄, Al, Zn, and Pb have been observed in the surface waters of Kississing Lake. A recent study on otoliths (ear bones) of whitefish in Kississing Lake measured the accumulation of trace element (Saquet et al. 2002, Nuclear Instruments and Methods in Physics Research). Concentrations of Zn up to 1000 ppm were observed in the otoliths suggesting the impact of tailings water.

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The Impact of Low-Moderate Anthropogenic Disturbance on Alpine Algal Communities

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Increasing human activity is having a profound impact on alpine ecosystems. Many surface waters in these areas show low productivity and algal species diversity, attributed to the short growing season, low temperatures and nutrients, and exposure to high UV irradiance. As a result, these systems have low resiliency and are particularly susceptible to disturbance. A number of studies show that alpine communities can respond to eutrophication by increases in algal biomass and noxious taxa, indicating that despite these harsh conditions, nutrients may play an important regulatory role. However for many of these systems, the impacts of eutrophication cannot be fully assessed because the natural spatial and seasonal ranges in algal community structure and biomass are not well characterized, particularly among interconnected lakes and drainage streams.

Lake O'Hara is one of numerous glacial lakes in Yoho National Park. Historically, human access to the catchment area has been restricted by Parks Canada (max. 200 persons/day), and limited early surveys of the lakes indicated very low productivity. Recently, however, Lake O'Hara has exhibited increased attached algal growth and nutrient levels in localized inshore zones not seen in headwater lakes upstream. There are several potential sources of eutrophication and other disturbances in the Lake O'Hara area: a lodge adjacent to the lake with tertiary wastewater treatment, a campground with outhouses and drain pits, and day use. The goals of this ongoing study are to: i) characterize the natural spatial-temporal variability in water quality, algal communities and other parameters in these lakes, and ii) evaluate potential impacts of human disturbance on these alpine systems by comparing samples from inshore/offshore zones in Lake O'Hara with those sampled from other lakes in the area which are exposed to different degrees of human disturbance.

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Advances in Genomics and the Environmental Fitness of Genetically Engineered Bacteria

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It has been over a quarter of a century since the first genetically engineered bacteria (GEBs) were developed using recombinant DNA techniques. However, there has yet to be a comprehensive compilation and review of experiments on key aspects such as how often GEBs have had an enhanced fitness under environmental conditions compared to their non-engineered parental bacteria. Such a review is needed since advances in genomics are already leading to the development of more complex and novel GEBs, and raising questions about the fitness of the next generation of GEBs. A review of environmental fitness studies of GEBs and their non-engineered parents identified 171 literature records over the period of 1986 to 2002. These records contained results from over 1000 experiments. Experiments were classified by whether GEB fitness was reduced, the same, or enhanced compared to parental bacteria. Classifications were based upon results of statistical tests and interpretations provided by authors. GEBs were found to have the same or lower fitness than their non-engineered parental bacteria in over 90% of experiments across a variety of terrestrial and aquatic ecosystems. An unexpectedly enhanced GEB fitness was found in less than 1% of experiments. However, much of the existing knowledge is based upon *Pseudomonas* species, transposon mutagenesis modifications, and studies conducted under laboratory conditions simulating northern temperate agro-ecosystems. Only 19 records (11%) contained results from experiments conducted in aquatic ecosystems. While it may continue to be a rare event when a GEB has an enhanced environmental fitness, it will be important to ensure our understanding of GEB fitness keeps pace with the tremendous advances occurring in fields like DNA shuffling, metabolic engineering, and the development of bacteria with minimal genomes.

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In-use Pesticide Concentrations in Canadian Tributaries of Lakes Ontario and Erie

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Pesticides are heavily used in agricultural production and in urban areas of southern Ontario. In 1998, surface water samples were collected bi-monthly from eight Canadian Lake Erie tributaries including: the Grand River, Kettle Creek, Big Creek, the Canard River, the Sydenham River, the Thames River, Big Otter Creek, and Turkey Creek. In 2000 and 2001, surface water samples were also collected from eight Canadian Lake Ontario tributaries including: 12 Mile Creek, Red Hill Creek, the Credit River, the Don River, the Humber River, Duffins Creek, the Ganaraska River, and the Trent River. Nine pesticides were detected in samples collected from Lake Erie tributaries and seven were detected in the Lake Ontario tributaries. In total, ten pesticides were detected including: mecoprop, 2,4-D, diazinon, pp-DDE, dicamba, metolachlor, atrazine, dimethoate, lindane, and metribuzin. Maximum concentrations of metolachlor, atrazine, dicamba and diazinon were 22 ug/L, 4.9 ug/L, 2.7 ug/L and 0.31 ug/L, respectively. Spatial and temporal pesticide patterns were observed indicating that there were differences in pesticide inputs occurring in urban versus agriculturally impacted watersheds. These results will be discussed in relation to aquatic life guidelines, pesticide use information, and possible implications to aquatic ecosystems.

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Water Quality Hydrodynamic Modelling of Rideau River

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The Rideau River is located in southeastern Ontario and flows northeast for 110 km from its headwaters in Lower Rideau Lake before discharging into Ottawa River at Ottawa. Approximately 70% of the watershed area is agricultural land and the remainder is either forested or urban. The primary uses of the river are for recreation and water supply, and there are no major industries located along the Rideau's course.

Rideau River provides vital recreational opportunities for boaters, fishermen, and cottagers who have enjoyed the benefits the river provides. With the increased urbanization and rural development within the Rideau River watershed these opportunities are being threatened.

Various studies show that there is a drop in water quality in many reaches of the river over a period of time. Although the Rideau is occasionally contaminated by a variety of pollutants, the main problems are nutrient overload and fecal coliform bacteria contamination. The nutrient problem causes excessive weed and algae growth and exists throughout the entire Rideau watershed. Planktonic organisms have attained significant densities along whole reach of the Rideau River.

Plant nutrients which are contained in both manure and chemical fertilizers are essential to a farm operation. However, improper use of nutrients can lead to soil-nutrient and feed-ration imbalances and can cause water quality problems both locally and downstream. Since the 1970s, it has been recognized that the Rideau River is nutrient enriched and that it is eutrophic, as indicated by algae blooms and excessive aquatic vegetation. The data show that the water quality degradation problems of Rideau River tend to be highest in the summer months, due in large part to significantly lower flow rates as well as, to a lesser extent, higher water temperatures.

A research project is currently being carried out at University of Ottawa to model the algal growth and ecological interactions of the Rideau River. Water quality hydrodynamic modelling is a useful tool in the assessment of the quantitative responses of the river to various human interventions in the natural ecosystem. In this project we are using a two-dimensional depth-averaged hydrodynamic and transport model: Modeleur, developed by Scientific Research Institute (INRS-EAU), Quebec. A model for growth and transport of algae is planned to be incorporated in the existing hydrodynamic model. Data for various water quality parameters is available as many agencies such as Parks Canada, Environment Canada and University of Ottawa have been involved in water quality and ecological research in the Rideau River for the past few years.

Currently, flow modelling of the lower reach of the Rideau River is in progress. Water quality model of Rideau River could be useful to assess the flow and water quality modelling and the ecological interactions of various living organisms and parameters in the Rideau River, which would otherwise be extremely expensive to evaluate in the field or laboratory.

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A Study for Integrated Water Resources Pollution Control in Central Area of Isfahan Province in Iran

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Extensive demand for water due to growing population and agricultural and industrial development in some areas of Iran, along with climate change, intensifies the need for integrated water resources management and pollution control.

In this paper, the results of a case study for development of a master plan for water resources pollution control in central area of Isfahan Province in Iran are presented. The study area has been faced with population growth and rapid expansion of agricultural and industrial activities. For many years, this complex system of resources and users has been managed without long-term plans that have resulted in considerable environmental difficulties and problems. The major components of the system are as follows:

- Surface water resources including Zayandeh-rud River with an average annual flow of 1600 million cubic metres which is the major artery in the area
- Groundwater resources
- Point sources of pollution such as effluent discharges and plumes generated by solid waste disposal sites
- Non-point sources of pollution such as runoff from agriculture lands and urban runoffs

Shares of contamination by different sectors are determined based on the share of water use, the available data, engineering judgment, and comments of experts in different agencies in charge of supply, distribution, collection and use of water. The outline of the plan and the major proposed projects are summarized as follows:

- Source Reduction
- Demand Management and Capacity Expansion
- Human Resources Development
- Monitoring and Sampling Network
- Research and Technology Transfer
- Institutional Changes and Improvement of Legal Framework

Different projects that are linked to each sector with their impact on water pollution reduction and the budget associated with each project are defined. Other projects which have an indirect impact on sustainable water supply and demand as well as projects aimed at monitoring and assessment, data collection and sampling, research and technology transfer are proposed.

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The Watershed Report Card: A Functional Approach to Watershed Assessment

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A coalition of concerned citizens, professionals and government agencies has developed the Watershed Report Card for use by community groups and schools to assist groups in learning what a watershed is and how it functions, as well as assisting them in targeting priority areas for action, monitoring and restoration. The Report Card was designed to lead groups through observation and evaluation of quantitative and qualitative measurements of their watershed to understand the natural limitations imposed by climate and geology. The strength of the Report Card is that it combines environmental assessment with community participation. Groups are encouraged to develop a long-term vision for the community and the watershed and to recognize the influence, both positive and negative, of human impact on the ecology of their watershed.

The Watershed Report Card consists of four linked documents. The first three—the bronze, silver and gold levels—relate to inventory, assessment and action; the fourth—a teacher's guide—was designed for use in senior elementary classes. This poster will provide an overview of the framework of the Report Card and the tools that were designed to assess the health of the habitat and organisms using the watershed. The overall structure of the Card is based on a functional approach to watershed assessment that employs ecological principles that integrate the components and processes of aquatic and terrestrial systems. It is organized along a modular theme with separate 'toolboxes' for key watershed components: streams, lakes, wetlands and terrestrial environments. The tools are based on protocols that provide both a snapshot of ecosystem health as well as defensible monitoring and assessment procedures. Recent directions in research and education will be presented, including a groundwater module.

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