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March 2007 Edition 1, Volume 3

canadianwaternews

Inside Canada's sewers

Finding a cheaper way to distribute water

Unmasking a new family of carcinogens

CWN's first infrastructure workshop

Taking a closer look at arsenic

Paying the price for safe drinking water

CANADIAN WATER NETWORK
RÉSEAU CANADIEN DE L'EAU

FOCUS ON INFRASTRUCTURE

CANADIAN WATER NETWORK
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canadianwaternews
A publication dedicated to infrastructure research undertaken by CWN researchers, students and partners.

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A message from the Scientific Director

The networks of pipes and pumping stations that are responsible for the treatment and transportation of water are coming to the end of their functional life. The Canadian Water and Wastewater Association has estimated by the year 2012 Canada will have a water infrastructure deficit of $88 billion dollars. Toronto alone has an immediate need for $800 million in repairs that will require a dramatic increase in property taxes for businesses and homeowners. Upgrading Canada's water and wastewater infrastructure is of paramount importance to maintain the sustainability of Canada's water supplies and ensure the country's economic prosperity.

The CWN has built a national, multi-disciplinary network of water researchers and partners to develop innovative technologies and management strategies to combat both the financial and technical challenges of our infrastructure deficit.

Our teams of researchers, students and partners in industry, government and non-government organizations are working together on several projects to:

- develop and evaluate new drinking water technologies;
- extend the life of existing infrastructure by improving conservation and demand practices;
- implement cost-effective monitoring of aging infrastructure;
- develop cost-effective solutions for providing drinking water and wastewater treatment in small and rural communities. These technologies and processes will have particular benefit for aboriginal communities;
- develop innovative techniques for storm and wastewater management and treatment.

This magazine, the third in a series, highlights some of our esteemed researchers and their efforts. Together our researchers, students and partners are developing innovative solutions to Canada's infrastructure problems.

We would like to thank you for your continued interest and support in the Canadian Water Network and look forward to many more years of collaborative success.

Mark Servos, Ph.D.
Scientific Director
Canadian Water Network

From the Editor

Canadian Water Network: Working in partnership to solve Canada's $88-billion water infrastructure deficit

Municipalities across Canada are facing major challenges when it comes to delivering safe drinking water and treating wastewater from our homes, industries and farms. Fortunately, they are not facing these challenges alone.

The Canadian Water Network has made it a priority to work with local communities to provide cost-effective and practical solutions for dealing with aging infrastructure, meeting new requirements for drinking water and wastewater management and responding to the impact of climate change on water resources.

For most Canadians, water infrastructure is "out of sight, and out of mind" although it is critical to our daily lives. This infrastructure includes the water treatment plants that purify our water, the underground water mains that transport water and the towers and reservoirs that store water. It also includes the sewer pipes that take away wastewater and the sewage treatment plants that treat wastewater before returning it to the environment where it often becomes the source of water for communities downstream.

Canada's water infrastructure was built 50 to 100 years ago, and in many communities this infrastructure is coming to the end of its design and operational life. According to the Canadian Water and Wastewater Association, this will lead to a water infrastructure deficit of over $88 billion. It's an overwhelming financial burden for any municipality, small or large.

The Canadian Water Network is taking a new approach to deal with these challenges. The Network's funding makes it possible to assemble academic experts from multiple scientific disciplines, including civil engineering, biology, hydrology and economics. Together, they collaborate with all levels of government, utilities, agricultural users, cottagers, industries, Aboriginal groups and others to come up with solutions that can realistically be put into practice.

David Cotter
Executive Editor

Infrastructure Facts

- There are an estimated 700 water main breaks per day in North America costing roughly $1 billion a year.
- Between 35-50% of water is lost due to old, leaky pipes.
- Water use in the 20th century has increased more than six-fold and continues to increase about twice as fast as the human population.
- Canadians use 1,650 cubic meters of freshwater per capita each year—double the average European rate.
- Canada flushes about 200 billion litres of raw sewage into its waterways every year, enough to fill more than 40,000 Olympic-sized swimming pools.
- About 18% of Canada's urban population (40% in Atlantic Canada) live in municipalities that do not provide sewage treatment.
- Inadequate equipment at First Nations' reserves poses a significant risk to quality and safety of drinking water.
- During the summer, about half of all treated water is sprayed onto lawns and gardens.

Letters to the Editor

Infrastructure Workshop

I had the pleasure of being invited to join the group of Canadian Water Network students and young professionals participating in the Southwestern Ontario Infrastructure Workshop in September 2006.

Water infrastructure is critical for the well-being of all Canadians. Our communities are facing challenges such as aging infrastructure, increasing urbanization and the potential impacts of climate change. It is necessary to engage and educate the next generation of water professionals to enable the development of innovative and sustainable technologies for future infrastructure needs.

The workshop provided participants with hands-on experiences in a diverse array of water-related technologies. They learned about source water protection, water and wastewater treatment and even how the Great Lakes-St. Lawrence Seaway System is operated. I was equally impressed by the leadership demonstrated by the students involved in the organization of the workshop.

This workshop and the CWN bode well for the future of water management in Canada.

Sarah Dorner
Research Assistant Professor
Department of Public Health Director
Massachusetts Water Resources
Research Center
University of Massachusetts Amherst

Holistic understanding

Let me begin by expressing my gratitude to the Canadian Water Network for giving me the opportunity to attend the Southwestern Ontario Infrastructure Workshop. It was a week packed with every aspect of water infrastructure.

The opportunity to visit a variety of different facilities including a drinking water treatment plant, Zenon, Trojan UV, and Niagara Hydro, to name just a few, made me aware of different aspects of infrastructure that I will take with me and apply throughout my career.

Although I am not directly in the field of infrastructure, I will be able to apply the information I learned on this workshop to future problems that I may otherwise not have thought about. By visiting a variety of facilities and hearing from experts in the field, I now feel I have a more holistic understanding of how water is gathered, treated and distributed on a municipal level.

I highly encourage students to participate in any of the upcoming workshops. You will learn more in a week that you could ever imagine.

Thank you,

Albanie Tremblay
M.Sc. (Candidate) Hydrogeology
University of Waterloo

Benefits of a CWN partnership

One of the advantages that Trojan has realized in working with the CWN is the ability to complement the expertise that Trojan industrial scientists and engineers have in UV systems design and performance with the expertise of other researchers within the CWN. These researchers have additional expertise in the by-product formation side of using disinfectants, in biofilm growth monitoring, and in other aspects related to optimization of an integrated disinfection strategy that uses UV together with chemical disinfectants.

Networks such as the CWN that bring together universities, industries and governments into partnerships for problem solving represent a successful model to complete the innovation process. In such networks, the university researcher gets the benefit of understanding the problem in the field from those who face the problem; industry gets the information needed to bring a technical solution to the marketplace; and governments get the knowledge needed to formulate meaningful regulation or policy based on sound science and technology validation. The CWN's multidisciplinary expertise ensures that companies like Trojan will turn to it in search of the world-class expertise needed to tackle the complex environmental problems requiring expertise not already within the company.

For a company, there is great benefit to working in partnership with the CWN. It is a guarantee for future clients and regulators that the technology or process has been critiqued and tested, not only by the company's internal experts but by independent professional scientists and engineers with credible expertise of their own. Additionally, it brings a feeling of confidence about the company, the technology and the ability of a collaborating Canadian research and development community to bring innovative solutions to complex environmental problems.

Bill Cairns,
Chief Scientist
Trojan Technologies

Collaboration

Municipal authorities continuously report the need for infrastructure assessment, maintenance and advancement to meet new regulation standards for water and wastewater treatment. This is a serious concern that will require significant changes in the way we manage and regulate our water infrastructure.

To help solve this problem, the CWN hosted a week-long, hands-on, interactive workshop for students and young professionals across Canada to learn more about the water infrastructure problems municipalities are faced with.

The workshop provided participants with the opportunity to learn about the protection, extraction, distribution and treatment of water and wastewater. The workshop focused on innovative technologies, exposure to both large and small-scale challenges and industrial user needs and impacts on utility operations.

Students and young professionals gained exposure to the complexity and range of factors affecting water and wastewater infrastructure decision-making processes. Further, these folks had hands-on training in emergency response planning, climate change impacts to water infrastructure and treatment processes.

In addition to the significant education value of this workshop, participants benefited from the opportunity to network with other students and experts from a variety of disciplines.

It is only by collaborating with each other and sharing our wealth of experience that we will be able to address the most pressing water infrastructure issues. Educating our students is imperative as they will be the leaders of tomorrow. This workshop is just one of the ways the CWN is equipping students with the tools they will need to tackle future water problems.

Dr. Graham Gagnon
CRC, Water Quality and Technology
Civil Engineering
Dalhousie University
Program Leader, Infrastructure, CWN

Networking

Networking is vital for career building and an important skill for graduate students who are beginning their careers. The CWN's first Infrastructure Workshop was an excellent week-long environment for students to build relationships with other professionals in the water and wastewater field.

The workshop created a networking environment on both a professional and personal level for the graduate students and young professionals. Participating students all had strong technical skills in their particular study areas, but this workshop brought them out of those silos to consider the entire water, wastewater and stormwater field. It helped them see the big picture of infrastructure and create contacts that could be used for future research or professional collaboration.

The water and wastewater industry in Canada is relatively small and tightly knit and many of these students will run into people they have met on this workshop throughout their careers at conferences, task forces and collaborative projects. I consider myself very fortunate to have helped create this networking opportunity by organizing the City of London's part in this workshop. I look forward to seeing many of the workshop participants in the future in various professional activities.

Carolyn de Groot, P.Eng.
Operations Engineer
City of London, Regional Water
Supply Division

The bigger picture

Participating in the CWN Southwestern Ontario Infrastructure Workshop 2006 was a very valuable event for me. The workshop helped me meet and develop a network of students, professionals, leading researchers and government decision makers in the water and wastewater industry.

Being a graduate student and passionate about water and wastewater treatment and water reuse I thoroughly enjoyed the workshop.

All of the presentations and tours on water and wastewater systems and industries enhanced my knowledge and understanding of the real-life application of advanced technologies and the factors affecting the decision-making processes. Sharing ideas with other participants from a wide variety of disciplines also helped me better understand the big picture of water issues. Through this workshop I met a great group of people and became very good friends with many of them.

I would like to thank CWN for organizing such an important workshop and hope that CWN will continue to organize similar events.

Pulin Mondal
PhD Candidate
Department of Civil Engineering
University of Toronto

Student initiatives

Updating our aging infrastructure is one of the most pressing challenges facing the City of London. We need bright, enthusiastic students coming out of graduate school who not only have the technical expertise, but a holistic understanding of the problem. This is why we have partnered with the CWN, to help educate students in the importance of multidisciplinary research.

Students are very important in solving our future water problems. The CWN Infrastructure Workshop, which London recently hosted, brought together some of the most dedicated students, broadened their horizons and exposed them to actual problems faced by municipalities. The CWN is equipping the students with the tools they will need after they finish school and enter the workforce.

CWN is also undertaking a variety of research initiatives of paramount importance to municipalities. By linking with CWN researchers, municipalities are able to tap into a wealth of expertise that we otherwise would not have access to. The CWN has developed a model which allows direct municipal input into research which is being carried out and is creating significant opportunities to help municipalities solve our infrastructure problems.

Peter Steblin, P. Eng.
General Manager of Environmental &
Engineering Services & City Engineer
City of London

Wet briefs

Great Lakes Sewage Treatment Doesn't Make the Grade

The Sierra Legal Defense Fund's recent Great Lakes Sewage Report Card was an appalling indictment of the way municipalities are treating a glorious natural resource.

Sierra Legal, a non-profit environmental law organization, analyzed twenty cities around the Great Lakes basin. They determined how each of the sites manage their sewage treatment and graded each accordingly. Out of the 11 Canadian cities, only Peel Region and Thunder Bay scored a B and B- respectfully. All others scored C+ and below. Toronto scored below average. Windsor was graded a D+, the second lowest in the study.

"The Great Lakes basin is one of the most important freshwater ecosystems on the planet—holding one fifth of the world's freshwater," said report author Dr. Elaine MacDonald. "Yet, the twenty cities we evaluated are dumping the equivalent of more than 100 Olympic swimming pools full of raw sewage directly into the Great Lakes every day."

The twenty cities evaluated, representing a third of the region's 35 million people, dump more than 90 billion litres of untreated sewage into the Great Lakes each year.

While many cities have made efforts to upgrade and enhance their sewage treatment, warning signs of unsafe waters have become a common sight in many urban areas. Parts of the freshwater ecosystem are also in danger.

Common and serious problems resulting in the lower grades related to municipalities' antiquated systems that combine storm water and sanitary sewers into a single pipe. These systems are prone to overflows and spills releasing raw sewage into the Great Lakes.

The report also analyzed the regions' inconsistent sewage treatment laws and policies and offered recommendations to ensure the protection of water quality in the Great Lakes.

"Although it would be easy to point the finger at the municipalities, the Great Lakes basin is a political quagmire that includes two countries, eight states, a province, dozens of tribes and First Nations and hundreds of local municipalities and regional governments," said MacDonald. "The only way out of this mess is to have all levels of government make a renewed commitment to upgrade our aging sewage system and conserve our precious freshwater resources."

This report is the first-ever ecosystem-based survey and analysis of municipal sewage treatment and sewage discharge in the Great Lakes basin. All information on collection, treatment and disposal of sewage was provided by the municipalities.

Canada and Climate Change

Canada is not prepared to handle the impacts climate change will have on our freshwater resources, according to a report by the WWF-Canada and the Sage Centre.

The report, co-authored by leading climate scientists Dr. James Bruce and Dr. Tina Tin, describes how Canada's seemingly limitless supply of freshwater is in actual fact, decreasing with global warming.

The report, *"Implications of a 2 degree C global temperature rise on Canada's water resources: Athabasca River and Great Lakes as case studies,"* describes how water flows in the Athabasca River in Alberta have decreased by about 20% from 1958 to 2003. As well, during record hot and dry years (from 1998 to 2001) the Great Lakes water levels have been consistently low. The report sites these two case studies as examples of what may happen if climate change continues to warm the earth: changes in rainfall patterns, more evaporation from lakes and rivers and less glacial flow resulting in lower lake levels and river flows.

"Ignoring global warming won't make it go away," says Julia Langer, Director, Global Threats Program, WWF-Canada. "You can't drink tar sands or coal, yet the fossil fuel industry is getting more protection from the federal and provincial governments than Canada's precious water."

This report, which builds on a growing body of research, assesses the risks to Canada with a global average temperature increase of two degrees. This is considered by the scientific community to be the danger threshold for environment and human systems. Already the average global temperature has risen 0.8 degrees since pre-industrial times and climate models predict that temperatures could rise two degrees between 2026 and 2060. However, this is not the entire problem. Different regions in Canada may see increases of between two and six degrees.

A two degree increase in temperature could have disastrous effects on both the Great Lakes and the Athabasca River. Warmer temperatures in the Great Lakes region will lead to more evaporation causing lake levels to decrease further. This can cause problems for local ecology hydropower production, ship navigation and recreation. Similarly, the Athabasca River is projected to drop by seven to ten percent with a two degree increase in temperature. This problem is compounded by the amount of water withdrawn by the oil sands industry, an industry that continues to grow and needs more water. Without more environmentally-safe practices, the oil sands industry will not be sustainable.

"Canada's fastest growing source of global warming pollution—the Alberta tar sands—is boiling off the very water supplies it needs, and in Ontario, burning coal for electricity is undermining access to clean hydropower," says Langer. "Only decisive action to dramatically cut fossil fuel pollution can stop this tragic irony."

"Canada urgently needs to better understand the risks and costs of climate change to its economy and quality of life," says Louise Comeau, Climate Project Director, Sage Centre. "In the absence of a full analysis, such as the recent report out of the UK by Sir Nicolas Stern, we offer this report as one contribution and call on all governments to move immediately to implement our recommendations."

Gordon Miller Addresses Great Lakes Concerns

The (Ontario) Environment Commissioner, Gordon Miller, traveled to Hamilton City Hall on Tuesday December 5th to discuss growing concerns regarding pollution in the Great Lakes. The meeting is part of a series of public forums that are occurring in cities along the Great Lakes.

The Commissioner invited local water experts to discuss the sustainability and future of the Great Lakes. During the evening he opened discussions to include local residents. Roughly sixty people joined the Commissioner to talk about their personal concerns, to question policies and debate steps to help remediate the Great Lakes.

"We wanted to come and find out what are the local concerns." Miller said at the forum. "But most important, what I need from people that live in cities on the Lakes, are suggestions they have for improving the situation and these problems."

The Great Lakes hold approximately 20% of the world's fresh water, making it the world's largest supply. The region is home to 35 million people, on both sides of the border, and about 30% of Canada's total population. Each day, the Great Lakes basin accounts for approximately $1 billion in trade between the United States and Canada.

Increasing concerns about water quality, intensification of urban development, water diversion and allocation, climate change, pollution, beach closures, loss of shorelines and ships introducing invasive species are just some of the problems surrounding the Great Lakes.

To combat these problems Miller has formed a partnership with Pollution Probe, a non-governmental organization, to tour cities around the Great Lakes and find out what the local concerns are and how they relate to the big picture.

"There are a number of scientists who are concerned that we are very close, if not at the tipping point, where we need to do something in order to protect the Great Lakes," explained Rick Findlay, Director of the Water Programme at Pollution Probe and Canadian Water Network Board Member. "Our work with Commissioner Miller will help kick-start the process."

These meetings are happening at a critical time as the Great Lakes Water Quality Agreement between Canada and the U.S. is under review. This agreement, under the Boundary Waters Treaty, is a commitment by governments to help restore and enhance water quality in the Great Lakes basin. Requirements include eliminating almost all persistent toxins, such as PCBs, as well as addressing concerns of runoff from land, contaminated sediment, airborne pollutants, contaminated groundwater and invasive species.

The Commissioner has traveled to Kingston, Windsor, Hamilton and Thunder Bay. As a result of the success of the forums, the Commissioner will continue the tour, adding more cities in the New Year.

Inside Canada's sewers

How a made-in-Canada system can save municipalities money

Canadian Water Network researchers are developing an Internet-based system for a new technology that allows municipalities to take detailed images of aging underground sewer systems. It will help cash-strapped communities prioritize billions of dollars in infrastructure repairs.

Confronted with an estimated multi-billion dollars in sewer system repairs over the coming decade, Canadian municipalities face two very daunting tasks. First is finding the money. The other is determining which repairs should be done first and which ones can wait.

The Canadian Water Network is working with Ontario municipalities to help solve the latter. The CWN is providing support and funding to university researchers in Ontario and New Brunswick to evaluate a revolutionary Sewer Scanning and Evaluation Technology (SSET) that provides the clearest and most detailed images of the inside of sewer and storm water pipes. The project is also developing a back-end Internet-based data management and decision-making system that can be shared by municipalities across Canada.

The CWN researcher heading the project says there is an urgent need in Canada to assess and repair aging waste distribution systems, which he describes as being in a "significant state of deterioration."

"If our sewer waste leaks out of the cracks in buried pipes, we end up polluting our environment and compromising public health. If ground water leaks into sewers, tax payers can end up paying significant dollars to treat million of liters of clean water before it is discharged back into the environment. System deterioration also increases the risk of basement flooding, sink holes, street and building damage and traffic disturbances," says Dr. Mark Knight, a civil engineer at the University of Waterloo.

The need to upgrade wastewater infrastructure is being driven by several factors, including stricter health regulations and environmental standards, as well as more people living in downtown city cores and sprawling suburbs.

Climate change will also aggravate the problem. If high intensity rainfalls become more common as predicted, it will contribute to more storm sewer overflows.

Niagara Falls first test site

The City of Niagara Falls is the first Canadian city to evaluate the SSET. The city has entered into a public-private partnership with Pipeflo Inc. of Stoney Creek, Ontario to bring this new technology to Canada to inspect the City's 412 km wastewater network over the next four years.

This will be the first time an entire city's network has been inspected with SSET in North America. "In Europe, which is ahead of us in this area, they believe you only have to inspect 10 percent of your total network to predict the condition of the rest of the system. This rule has never been tested," Knight says.

SSET consists of a 360 degree digital scanner on wheels that moves through the sewer pipes. The camera scans the pipe wall millimeter after millimeter, producing a continuous side scan of the pipe. The SSET measures and records its precise vertical and horizontal movements, ensuring that all images are spatially correct. The still images and video collected by SSET are later coded for pipe defects or deterioration.

Municipalities currently inspect the inside of sewer pipes using Closed Circuit Television (CCTV), which only provides a forward-looking view of the interior. With CCTV, the operator codes defects during the actual inspection.

A key component of the CWN project is the development of a non-proprietary SSET database that can be transferred from one technology supplier to another. Easy to access and upgrade, the high quality database will be the first of its kind in North

America. The research team is also developing generic software that can be used at other sites across the country. It will include pipe deterioration, forecasting, predication and cost models.

"We've also developed software for the City of Niagara that will check the defect coding for accuracy so the city can start making decisions with regard to its system. The city would never have been able to do this on its own," says Dr. Knight.

"Out of sight - out of mind"

Dr. Barry Adams, professor of Civil Engineering at the University of Toronto and a participant in the CWN project, says because urban water infrastructure is largely buried and hidden from public view, there is a temptation to take it for granted – "out of sight, out of mind" – except when major catastrophes occur.

"The alternative to crisis management," he says, "is ongoing condition monitoring, data analysis, modeling and planning on the basis of a true understanding of the condition, behaviour and performance of infrastructure systems."

Knowing exactly what repairs are needed and how much they will cost is a daunting exercise. Dr. Knight says municipalities have used inconsistent and inadequate methods of collecting data, and some lack an inventory of their infrastructure condition. Current CCTV images and defect coding does not allow for non-subjective evaluation of defect changes over time.

The CWN project will give municipalities a much better idea of how sewers deteriorate. Dr. Knight says this will result in more informed decision making with respect to repairs and more efficient use of taxpayer dollars.

"The first thing taxpayers will get is a better operated system," says Dr. Knight. "With less cracks and leaks in the pipes, there'll be less pollution."

CWN provides more than funding

The CWN's focus on multidisciplinary research and networking has enabled Dr. Knight to assemble a diverse team of infrastructure asset managers, technology suppliers, researchers and practitioners. "As the project grows, I see it being more interdisciplinary," he says.

The CWN has also provided financial and logistical support for students to participate in educational workshops and get hands-on training in applied research. As a result, Dr. Knight has two full-time Ph.D. students and had two co-op students working with him.

The first year of the project focused on data collection. The second year of the project will focus on software development, database population and the development of decision-making rules. Additional Ontario municipalities will begin testing the technology in 2007.

SSET Municipal Partners

City of Waterloo	City of Hamilton
City of Windsor	Region of Halton
City of St. Thomas	City of Kitchener
City of Welland	City of Burlington
Region of York	City of Vaughan

Plugging the leaks – and keeping pathogens out

Municipalities are struggling to keep pace with the constant repairs and maintenance of aging water distribution systems. Research has shown, however, that these repairs could be letting pathogens and chemicals into the drinking water. The Canadian Water Network is working with communities to safeguard against this threat.

A team of Canadian Water Network researchers is working with municipalities across the country to ensure pathogens and chemicals do not seep into the drinking water supply during routine repairs on water systems.

Municipalities of all sizes are trying to keep pace with the mounting repairs needed on aging public infrastructure, including water and sewer systems. But with the ramp-up in repairs and maintenance comes an increased risk that drinking water will become contaminated and people will become sick.

Dr. Michele Prévost isn't working in the lab to resolve this problem. Rather, the École Polytechnique de Montréal civil engineer and her team are on site at full-scale distribution systems in Laval, Montréal, Hamilton and Saskatoon to improve practices and procedures that can be replicated in other municipalities.

"CWN has had the courage to fund really tough field work. This type of research doesn't always result in published scientific papers like lab experiments do, but the results will be directly useful to utilities in protecting the health of citizens," says Dr. Prévost, who holds the Natural Sciences and Engineering Research Council Industrial Chair on Drinking Water at the university.

Two epidemiological studies in the 1990s by another CWN researcher, Dr. Pierre Payment, found that many gastrointestinal illnesses can been linked to deficiencies in Canada's water distribution system. In a journal paper, published in 1999, he stated that: "While the water that leaves the treatment plant is usually of very high quality, water in the distribution system can be significantly degraded by the intrusion of contaminated material during repairs, through illegal cross-connections, or during pressure loss in part of the system."

Dr. Prévost is taking steps to minimize this contamination. During the first phase of her CWN research, she studied the potential for contamination during the repair of links or broken water mains, periods when the distribution system is open and vulnerable. The research examined repair procedures such as hydrant flushing, pipe replacement and closing valves to isolate a section of a broken main.

"When you drive or walk by a site where they're repairing mains, you'll certainly understand very quickly what we mean by contaminants from the soil. The water and the sludge at the bottom of the pit possibly gets into the system," says Prévost.

The research found that under very clean conditions and strict guidelines for replacement or repairs, contamination is minimal. However, under certain conditions, even with good protocols, some contamination can occur and that procedures for repairs should be modified to minimize this possibility.

Chantal Morissette, Division Chief, Drinking and Waste-Water Distribution Division, with the City of Montréal, says Dr. Prévost's team has helped train their staff about the risks and potential contamination during pipe repairs and routine operations. The department has since changed a number of its procedures.

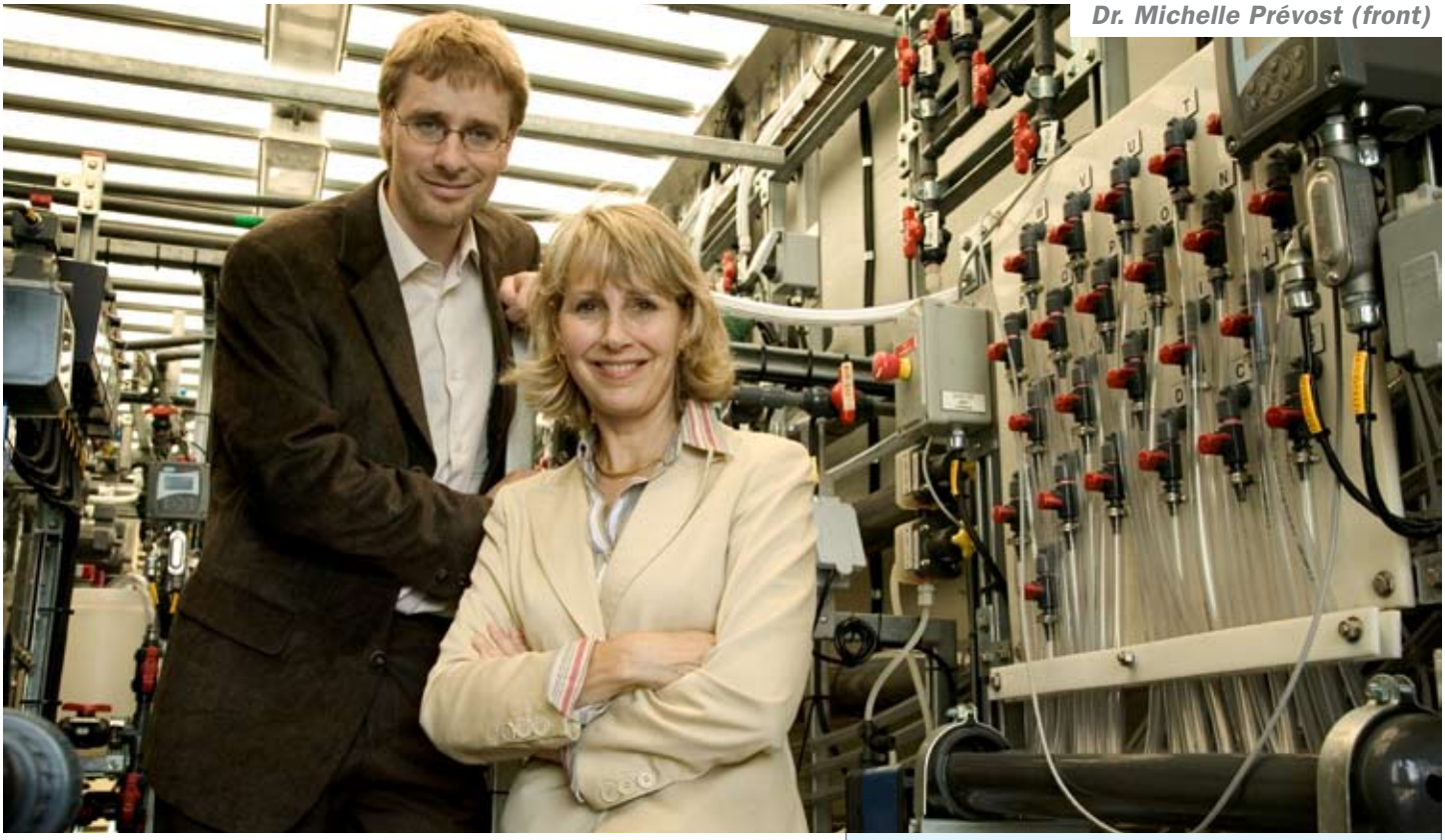
"The research helped us understand the risk and potential contamination during water pipe repair," says Ms. Morissette. "As a result, we have better calculated the risk and adjusted the treatments. It has now become part of the way we think and deal with problems."

For example, Dr. Prévost's research found that planned repairs have minimal risk of contamination and as such, adding chlorine to disinfect a certain pipe section may not be necessary. Chlorine also doesn't kill the most resistant pathogens. This led Ms. Morissette's staff to recalculate the dosage and concentration of disinfectants they put in the system, which has the added benefits of reducing costs while minimizing the environmental impact.

Identifying the leaks

Now in the second phase of the project, Dr. Prévost is studying how contaminants get into the system through numerous holes. These holes or leaks are a result of aging infrastructure or poor connections.

Problems don't usually occur when the underground water system is pressurized. If there is leakage, it's from water seeping



Dr. Michelle Prévost (front)

out of the system. Problems arise when maintenance crews clean out the system or close valves, which causes the pressure in the pipes to drop. When the pressure is negative, contaminants can get sucked into the system.

This research, expected to be completed in spring 2007, is investigating the importance, frequency and extent of transient pressures under regular operations of the system. Dr. Prévost says she hopes this research will demonstrate a link between older distribution systems, transient pressures and the incidence of gastrointestinal illnesses.

The research could also result in new procedures to minimize negative pressures during routine operations. While flushing is effective in removing corrosion and substances that may be growing in the water, she says it must be done in a way to minimize the intrusion of other contaminants into the system.

Canada's aging public infrastructure is a major driver behind the CWN research. "There has been very little investment in the water treatment infrastructure and even less in the buried infrastructure," says Dr. Prévost. "The infrastructure is in a very poor state and is in urgent need for renewal. The opportunities for water contamination will only increase over time." Montréal estimates it will cost up to $4 billion to repair its buried infrastructure over the next two decades.

The CWN project will also help municipalities prioritize those expenditures. "We need to figure out where the risks are and where we should put our efforts to minimize risk. Of course, the major economic value of this research will be in terms of public health."

Dr. Prévost believes her research will provide the background for regulatory changes in Canada and abroad. In the United States, for example, the Environmental Protection Agency is reviewing its water distribution regulations and has recognized the importance of the CWN research. Dr. Prévost expects Canada will follow suit. "Once the research is done, Health Canada will address the issue as well. This research will have a definite impact on our regulations, if it hasn't already."

Bringing together experts that can get the job done

Dr. Prévost's research is benefiting from the talents of a multidisciplinary team from across Canada.

She credits CWN with bringing together researchers from civil engineering, theoretical and applied hydraulics and microbiology from several Canadian universities. Dr. Prévost's team is working with the universities of Toronto and Saskatchewan and have recently collaborated with Brock University to look at the economics of their recommendations.

"Before the CWN we didn't have much interaction with academics in Canada," Prévost notes.

The CWN has also been active in developing a network of young scientists in the area of clean water management through its funding and support of students. In Dr. Prévost's project, the CWN has funded six masters and one doctoral student.

Working in the field has been especially beneficial to students as they get hands on experience dealing with real situations. The CWN also funds special events where students across Canada receive training from senior researchers.

CWN's First Infrastructure Workshop

Safe, clean water is something many Canadians take for granted. We turn on our tap and expect that the water flowing from our faucets is safe. Yet few of us give any consideration to the networks of pipes hidden beneath our communities.

This is not the case for 29 graduate students and young professionals who gathered in southwestern Ontario in late September to attend the Canadian Water Network's first Infrastructure Workshop. This week-long workshop allowed students and young professionals from across the country to study the growing problems of Canada's water infrastructure and promoted collaboration to help solve these problems.

"I would definitely say that it was an experience of a lifetime," said Albanie Tremblay, Master's student at the University of Waterloo. "Never again will I have the opportunity to see and learn so much about water infrastructure and the technologies used."

Participants were able to trace water infrastructure from the source to the tap, looking at small-scale system challenges, large-scale infrastructure developments, and social and economic aspects of water management.

Participants were also given the opportunity to leave the classroom and get a first-hand view of various technologies used at field sites. After a presentation on how SSET technology can inspect the inside of water pipes and help municipalities save money by prioritizing the systems need for repair, the CWN took participants into the field to see how these specialty cameras actually work.

This is not only an infrastructure problem, but a public health concern as well. Each break or leak in a pipe potentially exposes clean water to contamination.

The last day of the workshop provided a rare opportunity to watch as city engineers fixed a water main repair leak in London, Ontario.

"I wanted to come on the workshop because I realized it would be an excellent opportunity for me to learn about the real-life application of advanced technologies in water and wastewater industries and to understand the factors affecting the decision-making process," said Pulin Mondal, Master's student at the University of Toronto.

Water main breaks occur far too often. There are an estimated 700 water main breaks every day in North America with a repair cost of over $1 billion dollars a year. By 2012 the Canadian Water and Wastewater Association estimates Canada's water infrastructure deficit will reach $88.4 billion dollars. The City of Toronto alone is facing an immediate $800 million bill. Residential and industrial property taxes are going to have to increase over 10% to pay this cost. This is a serious concern and many communities cannot afford the estimated bill.

This is not only an infrastructure problem, but a public health concern as well. Each break or leak in a pipe potentially exposes clean water to contamination.

One of the biggest obstacles in overcoming these problems is the lack of multidisciplinary research to address the issues. Canada's water problems are so complicated that we need interdisciplinary collaboration among all university departments to develop a holistic understanding of the problems and solutions.

Participants on this workshop came from a variety of backgrounds including biology, chemistry, engineering and hydrology. They were able to form connections between the disciplines and they now have 29 colleagues from across the country they can call on in the future to collaborate on water infrastructure issues.

"This workshop has been a very memorable experience for me because of the people that I met," said Kurtis Doney, a Master's student at the University of Saskatchewan. "It really connects you to the problems and puts everything into perspective."

The next CWN Watershed Workshop will be held in Alberta and will be hosted by CWN researcher Dr. Leland Jackson at the University of Calgary.

"It's not what you know, it's who you know that makes a difference"

Networking is a vital skill. The U.S. Federal Bureau of Labor estimates that 70% of all jobs are found through personal contacts and networking, only 10% through advertised jobs.

Networking is the most important way to build professional relationships, to form contacts, to make connections, to disseminate information and to find a job. However, networking is an intangible skill, one which universities do not teach in their lectures. So how do students learn the art of networking? By practicing, going to conferences and workshops and talking to professionals in the industry.

CWN, understanding how intimidating this can be for students, organized a networking dinner during the Infrastructure Workshop at La Casa Ristorante in London, Ontario to help students improve their skills. Participants were able to network with industry professionals, university professors and government officials over dinner.

"The dinner was a huge success," said Mark Servos, Scientific Director of the CWN. "It gave the participants an opportunity to talk to people already working in the industry and it gave the professionals a chance to talk to the future generation of water professionals."

"These workshops are a great learning experience and the networking dinner was really beneficial," said Annie Locas, past president of the Student and Young Professional Committee. "The dinner was a wonderful opportunity to meet with industry professionals and others, not in the context of a conference, but in a more relaxed setting. At conferences the professionals tend to talk to the researchers they know. So the students, unless they are really confident – and most of us are not – do not jump into a conversation. But this dinner was a really great experience because if you looked around the room the students were talking to professionals and making contacts."

The CWN also hosts two-day workshops on other intangible skills such as leadership and communications. For more information visit **www.cwn-rce.ca**

Arash Alkozai, University of Toronto

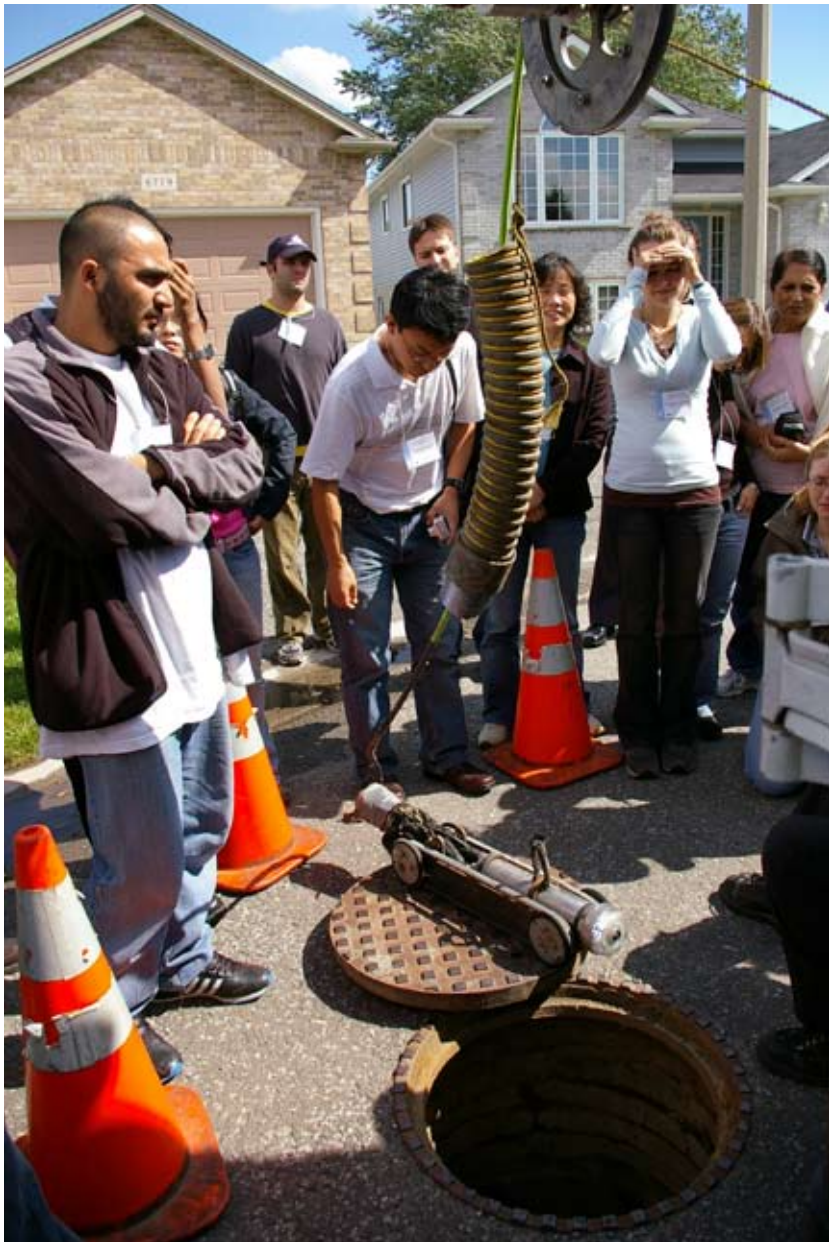
"I brought back an increased knowledge and awareness of the issues of the water sector. The tours and practical on-site examination filled many gaps. The case studies highlighted some of the important issues that surround the water sector and increased my awareness of them."

Sophie Pantin, University of Toronto

"At this workshop I learned a lot of technical things, but the most important thing is that I have been able to do a lot of networking. I think it is a really good idea to participate. This workshop helped me develop both personally and professionally. It was the best conference I have ever been to."

Pierre Grimaud, École Polytechnique

"I made contacts with other students and I discovered what is being done at different universities. At the worskhop you don't just sit at your desk with a narrow vision of only your project, you feel like you are being integrated into the water industry."



Victor Beaumonth, University of Waterloo

"What was really great about the workshop was that it was all encompassing. I loved how it was built to have every aspect of the water field. If you have any interest in water and water technology, I would highly recommend anyone to come out and expereince a CWN workshop."

Rodney Hughes, University of Waterloo

"I wanted to come on this workshop because I feel that I am in a very concentrated area of study and I am interested more about water networks from the source to the tap. I wanted to meet others and I have heard from other students who have been on previous workshops that they are a great time. And it was. I was able to listen to interesting talks from people from a whole range of spectrums."

Finding a cheaper way to distribute water

CWN study helping SaskWater to cut costs without compromising reliability or safety

A Canadian Water Network project is marrying economics, mechanical engineering and civil engineering to help rural water utilities use less energy, repair leaky pipes faster, monitor water quality and implement more equitable pricing strategies.

SaskWater
The Quality Advantage

Electricity – once considered a marginal cost in water distribution budgets – is becoming more of an issue as power rates rise and cash-strapped municipalities look for creative ways to cut costs without cutting services.

SaskWater, for example, spends about $1.5 million annually on the electricity needed to pump water to customers. The City of Toronto spends over $20 million each year.

Those energy costs for rural distribution systems could drop as a result of an innovative Canadian Water Network project underway at SaskWater to improve water supply management at the crown corporation. SaskWater provides water and wastewater services to municipalities, industrial users, public water boards and other users across the province.

"It costs a few cents in electricity per cubic metre of water, which doesn't sound like a lot, until you look at the billions of dollars in North America being spent on pumping operations. Because of the large economies of scale, this small cost can become quite huge," says Dr. Saeid Habibi, a mechanical engineer at McMaster University and lead researcher on the CWN project.

SaskWater is the main partner in the project, providing advice on how to structure the research and ongoing feedback as research results are presented to them by CWN researchers each month. The utility has also made it's distribution system available to the team for 10 years, providing a rare opportunity to test new ideas outside of the lab.

"We hope to see real energy savings as a result of this project," says Jeff Mander, Director of District Operations at SaskWater. "SaskWater is not a big company so we can't fund a lot of research. The CWN project is exciting because the research will have very practical applications that will help us in our operations. It also gives us an opportunity to tap into a national Network of expertise."

The two-year project brings together mechanical engineers, a civil engineer and an economist, along with six graduate students and post-doctoral fellows from four universities to work on five studies that aim to bring advanced water supply management to rural distribution systems.

In one study, researchers have developed mathematical models to analyze large amounts of data on water quality, flow and pressure, produced in real-time by advanced sensory instruments and control systems (SCADA system). They are focusing on water consumption patterns along the SaskWater's Saskatoon West water supply pipeline, which serves three industries, a village, a residential area, rural users and two golf courses. The goal is to come up with schedules that technicians can easily use on their existing system to regulate water flows more efficiently, which would save on energy costs.

"It isn't much good to come up with a numerical strategy that works in the lab. If it's unproven, an operator won't take the risk of interrupting water service to hundreds of thousands of homes and businesses," explains Dr. Habibi. "By working with SaskWater in a real-world laboratory, we can demonstrate unique approaches to optimization that gradually improve efficiencies in a very safe and guarded manner. Having a proof-of-concept will make it easier to extend this management approach to other provinces, or internationally."

How SaskWater Could Benefit

1. Lower energy costs
2. More equitable pricing strategies
3. Faster fault and leak detection
4. Improved water quality monitoring
5. Assistance in meeting new regulations for rural water

The case for smarter pipes

System breakdowns are another major cost and safety issue. Water utilities currently

use different methods for detecting a fault, including monitoring changes in flow and pressure. When a problem is detected, a field crew is sent out to drive the length of the line looking for evidence of a water leak, which they may or may not find. It's a time-consuming and expensive way to identify and fix problems.

The CWN project is working on a better way. Dr. Richard Burton at the University of Saskatchewan is testing two computational methods – one developed by CWN researchers (Ryan Lesychyn, Richard Burton and Saeid Habibi) – to determine which does a better job at detecting pump and valve breakdowns, pipe ruptures and leaks. The team has installed pressure sensors at both ends of the Melfort water supply pipeline, and is simulating leaks in an attempt to pinpoint the problem within a few metres.

"Our research goal is to develop new methods to allow water authorities to identify the leak, dig in the right spot and repair it quickly," says Dr. Habibi. "This is particularly suited for rural distribution systems because these lines run for very long distances and go through terrains that are not always accessible."

Other team members are studying how large pressure fluctuations can suck untreated water into a pipeline, and how operators can use sensors and SCADA systems to better monitor water quality and supply without stopping operations. The Saskatchewan government's introduction of stricter regulations for drinking water is requiring utilities to ramp up their monitoring.

"SaskWater's pipelines can be more than a hundred kilometres in length. For them to send someone out in the field to sample the water on a daily basis is difficult. So we're looking at how we can use sensory systems, information technology and telecommunications to facilitate the implementation of these new policies," adds Dr. Habibi.

"We hope to see real energy savings as a result of this project. SaskWater is not a big company so we can't fund a lot of research. The CWN project is exciting because the research will have very practical applications that will help us in our operations."

Jeff Mander
Director of District Operations
SaskWater

Better pricing strategies

Real-time monitoring has another major economic benefit. It will enable SaskWater to monitor water flows to determine peak load and off-peak pricing for water use. At Brock University, Dr. Mohammed Dore is marrying engineering data with an economic analysis of water users to help SaskWater develop more equitable pricing strategies.

"This research is timely because we're currently going through an extensive review of how we price water," says Mander. "We want to make our pricing more uniform across the province and make our pricing more transparent and readily understood by our customers."

Studies underway in BC, Ontario and Quebec

Helping Canadian cities plan for climate change

Working with global climate models, Canadian Water Network researchers have come up with ways to predict the potential impact climate change will have on future water supplies in specific regions across Canada over the next 100 years.

Scientists are predicting wide-scale environmental changes for the planet as a result of climate change, which began with increased greenhouse gas emissions at the start of the Industrial Revolution in the 1850s. But what impact will these changes have on rainfall patterns in individual cities and towns across Canada?

City officials in Victoria, BC are among the first to find out, as part of a two-year Canadian Water Network study to develop local weather models to forecast future water availability. The models will help municipalities plan for periods of extreme precipitation or drought, and the anticipated impact this will have on local water supplies.

An analysis of precipitation data over the past 100 years in Victoria reveals that precipitation patterns became even more variable in the mid 1960s. Summer months became drier – when demand for water is at its peak – and the winter and fall months became wetter. CWN researchers have had several presentations and held a number of meetings with city officials to discuss the results.

"Clearly, there are indications that climate change is occurring. We're not hitting the panic button, but we are accumulating information over the next few years that will allow us to make

some long-term decisions about how we manage our water," says Jack Hull, General Manager, Capital Region District Water Services, which manages the drinking water supply for the Greater Victoria area. It is the utility's first time partnering on a CWN project.

The CWN team is breaking new ground with the development of a new made-in-Canada statistical tools to predict local precipitation levels over the long term. Most countries currently rely on more macro General Circulation Models (GCMs). But GCMs only take into account latitude, longitude and ocean atmospheric interactions, such as winds, temperatures, ocean currents and precipitation, to predict the effect of greenhouse gases on large geographic areas over a 100-year period. And, they're much better at predicting temperature than precipitation.

"The problem with these models is that they're somewhat

"Clearly, there are indications that climate change is occurring. We're not hitting the panic button, but we are accumulating information over the next few years that will allow us to make some long-term decisions about how we manage our water,"

Jack Hull, General Manager,
Capital Region District Water Services

removed from reality. They are not applicable to small regions, and municipalities need this kind of data in order to incorporate climate change impacts into their strategic plans," explains Dr. Mohammed Dore, an environmental economist at Brock University specializing in climate change and its impact on public infrastructure.

As project leader, Dr. Dore is working with researchers at the University of Alberta and McGill University to develop new statistical techniques to "downscale" GCMs by plugging in local topographic features, such as the Great Lakes and the Rocky Mountains, which have a direct impact on local climate. The data is being used to develop local models for the greater Victoria region, the Fraser River Basin in BC, Montreal, QUE and Niagara, ON.

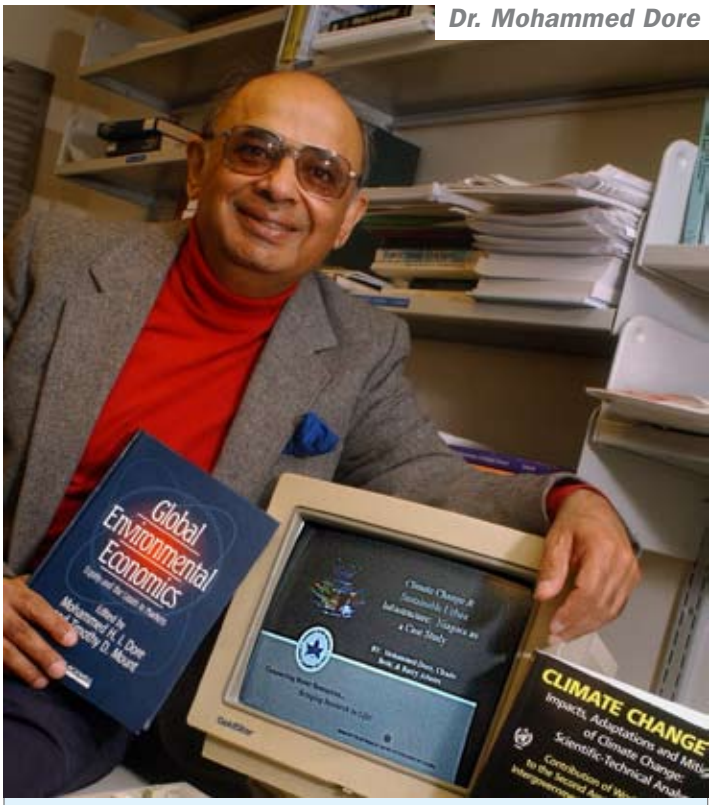
The threat of long-term drought

The Rocky Mountains aren't the only thing playing havoc with Victoria's weather. The CWN team is predicting a significant long-term impact from the tropical ocean current El Niño, which brings dry, warm weather, as well as La Niña, which brings cooler weather and more rain. Then there's an ocean phenomenon known as the Pacific Decadal Oscillation (PDO) – a body of warm water off the Aleutian Islands which has a major impact on North America. A warm El Niño combined with a warm PDO would likely bring years of drought to Victoria.

"We've exhaustively shown that these are major influences on Victoria's water supply," explains Dr. Dore. "In this project, we've established a statistical relationship, with a two-year lead time, that the city can use to forecast potential impacts on their water supplies. We presented the findings this year to the Water Services Department of the Capital Region District of Victoria and this information was new to them."

The findings from this project, and a related one at the University of Victoria, will help local government take steps to meet the future water needs of a growing population. If future weather patterns are predicted to differ significantly from historical patterns, it could prompt the municipality to implement aggressive conservation and management programs, increase reservoir capacity, limit population growth, require developers to build more water-efficient homes or consider alternate water sources, including desalination of sea water.

"Because of the nature of our water supply we rely on winter rains to fill our main reservoir to provide water over the period when the inflow to the reservoir is less than what we're using. If that's predicted to change in the future, we will need to plan for that," says Hull.



Dr. Mohammed Dore

Sewage overflow a risk in Niagara

High levels of precipitation, and more extreme downpours are predicted to put a heavy burden on aging sewer systems in Eastern Canada over the coming decades. It could well be the biggest challenge municipalities face as a result of climate change, according to Dr. Mohammed Dore, an environmental economist at Brock University.

A previous CWN-funded study, led by Dr. Dore, concluded that City of Niagara would have to spend up to $110 million to upgrade its wastewater storage and treatment infrastructure to handle much higher levels of precipitation anticipated as a result of climate change over the next 50 to 100 years.

Heavy rain storms are predicted to exceed the transport capacity of Niagara's sewer systems, much of which is more than 80 years old, resulting in sewage overflow in the lakes and backed up basements.

The study found that 118mm of precipitation in a single month will force Niagara's treatment plants to operate at 100% capacity. Precipitation beyond 118mm a month will cause storm water to overflow into the ecosystem.

"Municipalities have to form some strategic plans and incorporate climate change impacts into those plans, and increasingly the municipalities I'm talking to are doing that," says Dr. Dore.

Chinese, American and Canadian researchers team up to battle against water contaminants

International workshop in Edmonton, Alberta looks to address significant environmental and public health issues related to chemical contaminants in water.

Dr. Chris Le

Dr. Guibin Jiang

As China's economy continues to grow, the devastating environmental impacts continue to escalate. One of the most pressing environmental concerns is water. China faces disastrous pollution problems, shortages of fresh water, flooding and insufficient ability to supply water to northern regions.

These problems need to be rectified if the Chinese economy is to continue to grow.

Resolving these problems is exactly what a group of Chinese academics is trying to do. Many Chinese scientists gathered at the University of Alberta to collaborate with researchers in Canada and the United States to address pressing water issues in China and other countries.

What started out as an intimate gathering of 25 researchers from Canada and China to discuss water contaminants and health effects turned into a workshop with over 150 participants at the University of Alberta from July 5-8, 2006. The unexpected turnout of prominent and prestigious researchers reinforces the significance of water issues for researchers around the world.

"This particular workshop is really focused on knowledge development. These are critical issues for not only us as a province, but as a country and the world. The international component of this topic, the coming together of people, not only across Canada but from America and China becomes critical. It brings the scientists and the knowledge developers together into a collaborative relationship so that together we can do more than individuals."

Dr. Ronald Dyck, Assistant Deputy Minister of Alberta Innovation and Science

"A primary purpose [of this workshop] was to provide a stimulating forum for two strong networks to interact with each other, the CWN and the Chinese Innovative Research Consortium on Persistent Toxic Substances," said Dr. Chris Le, CWN researcher and organizer of the conference. "We achieved this by hosting this international conference." Both organizations jointly sponsored the workshop.

The most prominent topic of the Water Contaminants and Health Effects Workshop was arsenic, which the Word Health Organization has labeled as "the largest mass poisoning of a population in history."

"China and Canada have a long history of positive relationships with each other. We feel at home here," said Dr. Guibin Jiang from the Chinese Academy of Sciences. "With the Chinese economy we are facing quite a lot of environmental problems and we are pleased to invite scientists from the University of Alberta and CWN together to discuss these problems. Together, we can solve some of our problems and we will all benefit by the collaboration." Dr. Jiang is the Deputy Director for the Research Centre for the Eco-Environmental Sciences and a co-organizer of this conference.

Conference participants were not limited solely to researchers. Government officials, regulatory agencies, industry members and students also attended.

"This group, with their research and their analysis will be able to bring new ideas through the workshop to create opportunities to find ways we can more effectively use water," said Stephan Mandel, Mayor of Edmonton. "CWN's conference is so important because we need to be able to look at the problems and challenges we are facing and more forward. This workshop identified problems faced by all three countries and focused on combining the knowledge and expertise of everyone involved to find solutions," said Mayor Mandel.

"The importance of this conference is not just in the sessions, but networking as well. Networking is of utmost importance because that is how we do cutting edge research. We cannot be experts in everything," said Dr. Jonathan Martin, CWN researcher and Assistant Professor of Environmental Analytical Chemistry at the University of Alberta. "We are talking about important issues that reach beyond borders and effect people globally. It makes sense to

bring the people together to discuss solutions to some of the problems."

Dr. Le explained why this workshop was a success. "We have established a strong linkage with the leading scientists from Canada, China, Hong Kong, and the U.S. as well as with the government and industry partners," said Dr. Le. "We also showcased the cutting edge research that is carried out by CWN researchers. Our students and postdoctoral fellows obtained unique training through direct interactions with prominent scientists in their respective research fields. I am very proud of our students, postdoctoral fellow and staff who made this international workshop a huge success."

Students, researchers and industry professionals network during the poster session

In May 2006, Heath Canada changed their drinking water guidelines for arsenic from 15µg/L to 10µg/L with help from Dr. Chris Le's research. The guideline now coincides with the WHO (1993) and U.S. (2006) guidelines.

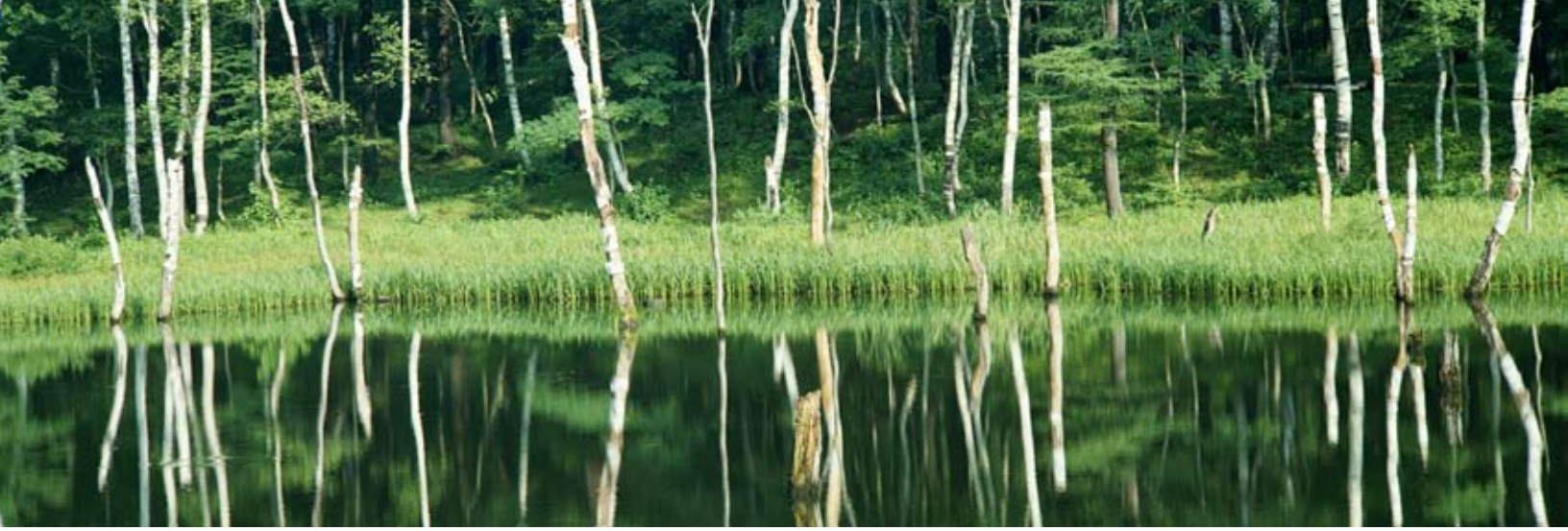
Arsenic, a naturally occurring chemical found in the Earth's crust, has caused the largest environmental poisoning in the world. Hundreds of millions of people are at risk of being exposed to high levels of arsenic in the Bengal Delta Region (Bangladesh and East Bengal, India). Chronic high levels of arsenic-contaminated drinking water have been linked to cancers (lung, bladder and liver), melanosis (white and/or dark spots on the skin), keratosis, skin lesions, hypertension, diabetes and even death. The most documented cases are found in Inner Mongolia, Taiwan, Chile and Bangladesh.

Arsenic is also a problem in China. As a result, it was one of the main session topics at the Water Contaminant and Health Effects Workshop. Presentations covered areas such as epidemiological investigations, speciation, toxicity and various treatments.

Almost all Canadians are exposed to small levels of arsenic in their drinking water. While health effects from high quantities of arsenic exposure are well documented, effects of low concentrations are not well known. This is where Dr. Le's work, along with partnerships he has formed with the CWN and the Chinese Academy of Sciences have come into play. Dr. Le is currently leading a CWN–funded project, Arsenic in Drinking Water-Speciation, Human Exposure and Heath Effects, to research the health effects of low levels of arsenic that Canadians are exposed to.

Timeline of countries adopting 10µg/L as their arsenic guideline

1993	2000	2003	2005	2006	2007
WHO	Germany	UK	Denmark	Canada	Bulgaria
			France	US	Croatia
			Greece	Hungary	Romania
			Italy	Portugal	Serbia
			Spain		Turkey



Building better wetlands

More efficient and affordable wetlands could cut wastewater treatment costs for farmers and rural communities

A team of Canadian Water Network researchers is discovering the untapped potential of constructed wetlands to treat manure and other wastewater – while helping farmers meet new environmental standards.

Are Canadian farmers getting the most out of their constructed wetlands to treat manure runoff and other wastewater from their operations? Apparently not, according to new research funded by the Canadian Water Network.

The discovery could prove to be a major money saver for Canadian farmers who must meet new environmental standards and farm management practices for treating manure runoff, washwater from dairy milk houses as well as domestic wastewater.

"Putting in a $100,000 treatment system isn't feasible for many small farm operations. That's why our research has focused on the economic feasibility of these wetlands in rural areas. How can we make them more robust, smaller, more affordable and easier for operators to manage – and at the same time meet environmental standards?" asks lead researcher Dr. Robert Gordon, a Canada Research Chair in Agricultural Resource Management at the Nova Scotia Agricultural College (NSAC).

Dr. Gordon is working with colleagues at NSAC, Dalhousie University, McGill University and University of Guelph, along with provincial government and industry partners, to improve the efficiency of constructed small-scale wetlands year-round. An agricultural engineer by training, he has helped design and construct more than 50 wetland systems. He also developed many of the innovative environmental management processes in use among Atlantic Canada's farming community.

The CWN research project enabled the team to train eight graduate students and construct some of the research infrastructure, including the wetlands. "The CWN has really helped us to build capacity and work more closely with our industry partners in some of these areas."

Constructed wetland systems are environmentally friendly and provide an economical way to filter sewage and wastewater. These engineered systems are designed and constructed to use natural processes involving wetland vegetation, soils and the nutrient cycle to clean nitrogen and pathogens from the water. Constructed wetlands have been widely used in southern climates but their application in cooler regions has been generally limited.

The CWN team is studying the two basic types of constructed wetlands: subsurface flow and surface-flow systems. Subsurface flow wetlands move agricultural runoff or wastewater through a gravel and/or sand substrate. Surface-flow systems move effluent above the soil in a planted marsh or swamp.

"The attractive thing about these systems," says Dr. Gordon, "is once they're in the ground, other than a day or two of annual maintenance and some monitoring, they don't require a huge amount of attention. The key lies in ensuring they are designed and loaded properly."

To test what works and what doesn't, the team is using pilot scale wetlands at a working dairy farm at NSAC's Bio Environmental Engineering Centre in Truro, Nova Scotia. When it comes to constructed wetlands, one size does not fit all. Different types of wastewater are loaded into different wetland systems in different ways and at different times to come up with the best results.

Using Wetlands in the Winter

One surprising discovery from the CWN project is how well these human-made systems work in cold weather, dispelling a commonly held belief that it was best to store their wastewater in lagoons over the winter months. Cold weather has been a key deterrent against the wide-scale adoption of constructed wetlands in Canada.

The common practice in many regions of Canada is for farmers to load wastewater into their wetlands from mid-April to mid-October. During the winter months, wastewater is collected in a holding pond and then loaded into the wetland in the spring. As a result, wetlands work double-time during the growing season, and take a break during the winter. The challenge is the extra cost to the producer for this over winter storage.

That practice can now change. The CWN team found that wetlands work just as well, if not slightly better, when they're loaded year-round. The findings could result in more widespread adoption of constructed wetlands as an affordable and efficient way to meet new environmental requirements.

"When you're putting huge amounts of wastewater through the system during the growing season, they can become overloaded if it gets particularly wet," explains Dr. Gordon. "We had a big rainfall in September 2005 and that contributed to a substantial amount of loading that we didn't see with the continuously loaded systems because the volume we were putting through was much less."

Dr. Gordon and his team have been presenting their findings to the agricultural industry in Nova Scotia, with the goal of encouraging greater adoption of constructed wetlands across Canada.

"National initiatives like the Environmental Farm Plan Program, which are being implemented on most farms across Canada, has put more focus on how farms deal with wastewater – not just how it's generated, but how we effectively manage it before it leaves the farm. Our research will certainly help governments and the agricultural community meet these new requirements."

Project Partners

Canadian Water Network

Nova Scotia Farm Investment Fund

Nova Scotia Environmental Farm Plan Program

Nova Scotia Department of Agriculture

Agriculture and Agri-food Canada

Nova Scotia Federation of Agriculture

Dairy Farmers of Nova Scotia

Atlantic Swine Research Partnership

Centre for Water Resource Studies (Dalhousie University)

Bio-Environmental Engineering Centre

Surface-flow wetland

Unmasking a new family of carcinogens

CWN team seeks answers for unexplained increases in bladder cancer

A toxic mix of low-level disinfection byproducts (DBPs) could be increasing our risk of bladder and other cancers. But as a Canadian Water Network team is discovering, they are not the DBPs that Canada and other countries are currently regulating.

Dr. Xing-Fang Li is working with researchers and graduate students from across Canada to track down mysterious molecules that may be lurking in some drinking water supplies. Once unmasked and their effects on human health better understood, regulators can then take steps to introduce new safeguards against these previously unknown toxicants.

At issue are the byproducts produced by chlorine and other disinfection processes, which are essential for destroying pathogens in drinking water. These disinfection processes can produce trace amounts of chemicals which may be more dangerous to humans than the ones that are known and regulated.

Drinking water disinfection by-products have become a challenging public health issue because of conflicting epidemiological and toxicological evidence. Over 500 DBPs have been identified and only two – trihalomethane and haloacetic acids – are regulated in the US and Canada.

The problem is that many DBPs are in such low concentrations – in the parts per trillion or smaller – that they are difficult to extract and analyze. And, for the ones that are known, there is no epidemiological evidence linking them with bladder cancer.

Canada is attracting international attention from the United States, China and other countries for its groundbreaking work in this field. An earlier CWN study helped researchers to develop highly sensitive analytical techniques for separating and detecting

new DBPs. As a result of this project, it became possible for the first time to identify and quantify these compounds.

Dr. Li and colleagues from the University of Alberta, University of Waterloo and University of Toronto are focusing primarily on chemical compounds called nitrosamines, a potential group of human carcinogens. The team is using these new analytical techniques to test source water samples from the Grand River in Waterloo and the North Saskatchewan River in Edmonton and has already found nitrosamines present in one small drinking water system.

Dr. Li and Dr. Robert Andrews at the University of Toronto are evaluating 12 different disinfection treatment processes, including chlorine and ultraviolet radiation, to see how these compounds are formed, and how to minimize the production of DBPs by using proper disinfection process for specific types of source water.

"We have already developed the analytical methods that will help us to understand how new and emerging DPBs are produced, where they are produced and how toxic and nasty these compounds are. It could be that one compound at such a low

level has a minimal effect, but when you have low levels for several different compounds, the health effects could be more cumulative," explains Dr. Li, an analytical chemist working in the Department of Laboratory Medicine and Pathology at the University of Alberta.

Stomach fluids may create toxic mix

Knowing that DBPs are present in treated water is the first step. Determining how toxic they are to humans is the next challenge.

The CWN team is zeroing in on the minute amounts of chlorine found in tap water and how nitrosamines can be produced when this residual chlorine encounters the organic matter in stomach fluids. They are mixing tap water from two Alberta cities (Edmonton and Camrose) with gastric fluid and incubating the solution at 37˚C to mimic body temperature. The team has already observed the formation of some nitrosamine compounds under these conditions.

"In order to study the reaction we need the analytical method," says Dr. Li."We have a student who is developing a new method to extract these compounds in gastric fluid and we're confident we will produce a reasonably good method to analyze these gastric fluid samples. This is much more difficult than analyzing water samples."

"We also want to understand the potential hazards to humans so right now we have developed a rapid screening technique that examines the relative cytotoxicity (cell toxicity) of these new DBPs to the different mammalian cell systems," she adds.

Meanwhile, Dr. Janusz Pawliszyn at the University of Waterloo is developing onsite analytical methods that could be easily used to test water at treatment plants. He is also studying how to remove these compounds from drinking water, perhaps using a type of membrane filter.

Next steps

Dr. Li is optimistic that their research will eventually lead to better guidelines for new DBP compounds and disinfection technologies, but more research is required. She says both Health Canada and the Environmental Protection Agency in the U.S. are interested in working with Canada's academic community to find solutions.

"It's great to do this type of research as part of the Canadian Water Network," says Dr. Li. "The Network's emphasis on promoting excellence and networking made it possible for us to bring together the expertise we needed from across the country. Partnering with public health and regulatory scientists in particular is essential if you want your research to have a real impact on society."

"Because of our initial success, we are now collaborating with the EPA in the U.S. to look at more occurrences of these types of compounds in water systems in the U.S. and Canada. We are also exploring with Chinese researchers about possible collaborations to evaluate the Chinese water systems."

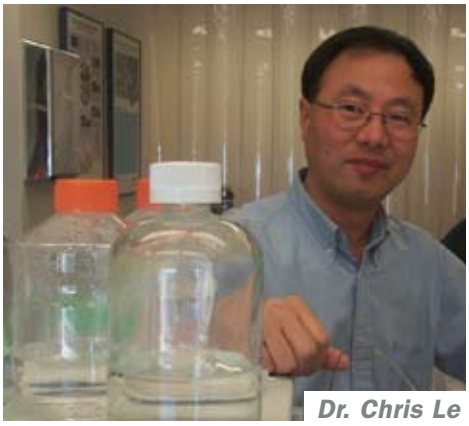
Dr. Xing-Fang Li
Associate Professor

Collaborators

National Research Council
Alberta Health and Wellness
Health Canada
Environmental Protection Agency (U.S.)
Canadian Water Network

Taking a closer look at arsenic

New map will identify arsenic levels across Canada



Dr. Chris Le

More than 30% of Canadians get their drinking water from groundwater, which in some communities contains very low levels of arsenic. Canadian researchers are now identifying where these communities are and the potential health risks to local residents.

There is no shortage of scientific evidence linking exposure to high levels of arsenic to serious health problems, and even death. Yet, little is known of the risk to humans who are exposed over the long term to low levels of this notorious chemical.

"It may seem like arsenic has been studied to death, but actually we know very little about how it causes various health problems. Partly, it's because we didn't have proper analytical tools to measure the effects from low-level exposure, particularly the cancer effects, notably skin, bladder and lung cancers," says Dr. Chris Le, the lead researcher on a Canadian Water Network project that is breaking new ground internationally in arsenic research.

Dr. Le is working with university and government collaborators in Canada and the United States on a four-year project to quantify the health risks people face from exposure to low levels of arsenic, which occur naturally in the environment. Although most Canadians are only exposed to low concentrations, under 0.005 mg/L, it's still not clear what level of arsenic is acceptable. The Canadian guideline for arsenic is 0.010 mg/L.

One of the first outcomes of the CWN project will be an "Arsenic Map of Canada", showing levels of arsenic in drinking water across Canada as well as population statistics. The research team is working with all levels of government to compile current data on well water and surface water. Health Canada will be able to compare the map with epidemiological studies to determine if cancer rates are higher in areas with higher concentrations of arsenic.

"We know where arsenic is for the majority of people who are exposed. We're now in the process of looking at smaller communities and the people who use well water. It's fewer people but far more water sources to examine. We're writing a report for the Alberta government and are working on one for Ontario and Atlantic Canada," says Dr. Le, who holds a Canada Research Chair in Bioanalytical Technology and Environmental Health in the University of Alberta's Faculty of Medicine.

A detailed map showing arsenic levels in major metropolitan areas and some smaller regions will be available later in 2007. The map will help water utilities and governments take action to reduce arsenic exposure.

Smoking and arsenic don't mix

While low concentrations of arsenic may have negative health consequences, it's difficult to find a direct correlation. Lifestyle factors such as diet, smoking and exposure to other environmental contaminants can also elevate the risk of cancer.

The CWN team appears to have found one important link, however. People who

are exposed to arsenic as well as other carcinogens may be at an increased risk of getting cancer. The reasons may be two-fold. First, when arsenic is present, the cells can absorb more benzo(a)pyrene – a carcinogenic chemical found in burning materials such as tobacco smoke – which causes even more damage to the cells.

CWN researchers also discovered that arsenic can inhibit or interfere with the body's natural ability to repair DNA damage in human cells, putting a person at an increased risk of developing malignant cells.

"Both of these findings are quite significant. Usually this type of research takes a long time and we're quite pleased that we've made such significant progress in just four years," says Dr. Le.

Measuring toxicity levels

One reason we know so little about arsenic, particularly in low concentrations, is because the analytical tools haven't existed to properly study it. Dr. Le and his colleagues Dr. William Cullen at the University of British Columbia and Dr. Kenneth Reimer at Royal Military College, have developed new techniques that combine chromatography with mass spectrometry to identify new arsenic compounds beyond the 20 that are already known.

These state-of-the-art techniques – now being used by researchers around the world – can detect trace levels of arsenic and provide insight into how arsenic binds to other molecules. In addition, Dr. Le and his colleague Dr. Michael Weinfeld, a biochemist at the Cross Cancer Institute in Edmonton, have developed a new technique to measure specific damage to cellular DNA.

"Some arsenic compounds are very toxic and others are non-toxic. What can determine their toxicity is how the arsenic binds to other elements. These analytical tools help us to first identify a new arsenic species, and secondly, assess their toxicity," says Dr. Le. Further, different arsenic species have different chemical behaviors in water. The information on what arsenic species is present in a particular source water will help water utilities determine the best process for removing arsenic.

The research has already helped Canada's largest gold mine, GoldCorp Inc. in Red Lake, Ontario, to identify arsenic compounds in their refining waste. The company's environmental engineers were trained to ensure that the correct arsenic removal processes are being implemented before the water reaches the lake.

"There's a lot of interest in North America and around the world in this research," adds Dr. Le. "For the scientific community, it increases our understanding of the mechanisms of action associated with arsenic and human health. And for public health officials, the research could lead to more informed decisions related to arsenic guidelines and treatment."

Other members of the CWN team include Dr. Graham Gagnon from Dalhousie University and Dr. Xing-Fang Li from the University of Alberta.

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Research Goals

1. To better understand how arsenic – when combined with smoking – can inhibit the ability of cells to repair themselves
2. To identify and characterize new arsenic compounds in groundwater
3. To develop a drinking water arsenic map that will identify arsenic "hotspots" in Canada and the populations of potential concern

Collaborators

Alberta Health and Wellness

Alberta Environment

Health Canada

National Cancer Institute of Canada

Environmental Protection Agency (U.S.)

Nebraska School of Medicine

Cross Cancer Institute (Alberta)

Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences

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