50th CENTRAL CANADIAN SYMPOSIUM ON WATER POLLUTION RESEARCH

BOOK OF ABSTRACTS

ADVANCES IN WASTEWATER TREATMENT TECHNOLOGIES AND APPROACHES

Promoting Excellence in Wastewater Treatment Plant Performance

K. HAGAN [1*], M. ANDERSON [1]

[1] *Grand River Conservation Authority*

The Grand River watershed has a population of about 985,000 that is expected to reach 1.53 million by 2051. There are 30 municipal wastewater treatment plants (WWTPs) that discharge their treated effluent into rivers in the watershed. Significant population growth will result in more wastewater being discharged into these rivers. It is imperative that wastewater effluent be high quality to ensure that river health continues to improve and watershed communities will continue to prosper. Good, economical wastewater effluent can be achieved through optimization, a continuous improvement process that invests in skills development of operators and managers to operate wastewater treatment systems more effectively. Since 2010, the Grand River Conservation Authority has been leading the Watershed-wide Wastewater Optimization Program (WWOP), which is an ongoing, voluntary program that encourages optimization to effectively tap the full potential of existing wastewater infrastructure while improving effluent quality. This presentation highlights the key activities of the WWOP: building a community of practice for information sharing on the status, issues and lessons learned; establishing voluntary effluent performance goals for watershed WWTPs; delivering optimization training through focused workshops and hands-on site activities to increase staff knowledge and skills; developing a framework for annual reporting of process and performance data for all watershed WWTPs as a means to gauge progress towards the voluntary performance goals and better define the impact of WWTP discharges on the river; and developing a strategy to transfer the successful approach and findings from the Grand River WWOP to the larger community in Ontario.

[*] Presenting author, khagan@grandriver.ca

High-throughput dewatering test (HTDT) for screening of polymer flocculants and optimization of dosage conditions

Ryan LaRue, Jeffrey Cobbledick, Emily Cranston, David R. Latulippe

Department of Chemical Engineering
McMaster University
Hamilton, Ontario

Sludge dewatering via polymer-induced flocculation is a key unit operation in wastewater treatment. The cost of the polymers is a considerable operational expense; thus an ongoing challenge in wastewater treatment is to identify the 'best' polymer and dosage conditions from a techno-economic perspective. The conventional approach is to use a series of simple jar tests. However, this method proves to prohibitively time consuming given the large number of flocculant types from the various suppliers. For example, SNF offers over forty different versions of their FLOPAM cationic polyacrylamide flocculant that vary in charge density, molecular weight, and structure. Inspired by the recent trend in the biotechnology industry towards small-scale, parallel, high-throughput test formats, we have developed a high-throughput dewatering test (HTDT) for screening of polymer flocculants and optimization of the dosage conditions. Our parallel approach uses a tumble stirrer device to achieve simultaneous mixing in 12-well microplates with the flocculation performance evaluated using capillary suction time (CST) measurements. As a proof of principle, we evaluated the performance of ten Zetag polymers from BASF over a wide range of dosages for three different sludge sources. All of the polymers tested displayed a decrease in CST with increasing polymer dosage, however there were significant differences in the overall trends between the ten polymers. Our work included an evaluation of the effect of multi-dosing for a subset of the polymers. Overall, significant opportunities exist for improvements in process performance as demonstrated by the considerable differences in flocculation performance.

Removal of CECs from Wastewater using Aclarus Ozonation Technology

M. DJAP [1*], A. DORAN [2], M. DORAN [2], V. YARGEAU [1]

[1] *McGill University*
[2] *Aclarus Ozone Water Systems*

There is a growing concern about contaminants of emerging concern (CECs) found in the environment. These CECs include pharmaceuticals, personal care products and illicit drugs that are often not easily removed using conventional treatment technologies. Aclarus has developed a low-cost, low energy ozonation system that may be applied to the treatment of wastewater. To test the system efficiency in terms of CEC removal when applied to wastewater treatment, the AOWWT-10 pilot unit was used to treat the effluent of the wastewater treatment plant in Peterborough, Ontario. Different operating conditions were tested using a full factorial design with two independent parameters: flow rate and ozone productions. Other variables were tested using parametric studies including ozone dose, effect of operating pressure, and CEC removal during the system startup. The oxidation-reduction potential and the disinfection level were measured for each condition tested. Wastewater samples collected pre- and post-ozonation were analyzed for the quantification of indicator compounds and illicit drugs by LC/MS-MS (Orbitrap XL, Thermo). Samples were also analyzed by Microtox tests to evaluate the change in toxicity levels during ozonation to evaluate the risk of forming toxic ozonation transformation products. Based on the results currently available, some of the operating conditions studied impact the removal of the CECs. A statistical analysis of the removals obtained and changes in toxicity observed will allow the determination of the potential of the technology at treating municipal wastewater.

[*] Presenting author, melissa.djap@mail.mcgill.ca

Response of bioelectrochemical systems to different substrates

W. HUANG [1*], Y. KIM [1]

[1] *McMaster University*

Bioelectrochemical systems (BESs) can be used as an alternative to conventional wastewater treatment to remove organics while recovering energy as direct current with microbial fuel cells or hydrogen gas with microbial electrolysis cells. BESs utilize exoelectrogenic bacteria to break down organic substrates and produce electric current. Acetate is widely accepted as the best substrate in BES experiments since exoelectrogenic bacteria are capable of directly utilizing acetate. While BESs are capable of oxidizing more complex organic substrates (e.g., organic acids, sugars and proteins), they are less effective in producing electric current than those fed with acetate. Previously, magnitude of electric current was used to evaluate BES performance. However, electric current alone is insufficient to show whether exoelectrogens directly utilize complex substrates or if other non-exoelectrogenic microorganisms in the consortia break the complex substrates down into usable acetate for exoelectrogens. While electric current only shows the activity of exoelectrogens oxidizing acetate, electrochemical techniques can be used to identify what other reactions are involved in substrate oxidation. We used electrochemical impedance spectroscopy (EIS), linear sweep voltammetry (LSV) and gas chromatography methods in addition to electrical current to examine the response of BES to a broad range of substrates, including monosaccharides, proteins and fatty acids, and whether exoelectrogens are capable to directly oxidize the given substrate. In a lab-scale experiment, EIS tests found that BES fed with non-acetate substrates showed greater charge transfer resistance, indicating that the exoelectrogenic bacteria are less effective at utilizing the substrates. We also confirmed that the BES was slower to reach peak electric current, and the electric current was lower compared to BESs fed with acetate.

[*] Presenting author, huangw23@mcmaster.ca

Microbial electrolysis cells for the removal of cadmium and chromium from wastewater

N. COLANTONIO [1*], Y. KIM [1]

[1] *McMaster University*

Heavy metal pollution can be a serious hazard to the environment and human health. Both cadmium and chromium in particular are highly toxic, even at low exposure levels. Concentrations of these heavy metals in wastewater are relatively low but can accumulate to high levels with continued applications of reclaimed wastewater or wastewater biosolids because they are non-biodegradable. Ideally, treated wastewater could be reused for agriculture purposes and groundwater recharge. As well, the biosolids from the treatment process can be used for land fertilization. However, conventional wastewater treatment methods cannot remove heavy metals without additional technologies, such as reverse osmosis or nanofiltration, making it difficult to reuse treated wastewater and biosolids. Microbial electrolysis cells (MECs) are an emerging technology for treating wastewater. With a small applied voltage, exoelectrogenic bacteria oxidize organic matter at the anode while water is simultaneously reduced to hydrogen gas at the cathode. In addition to the water reduction reaction, the MEC cathode reduces heavy metal ions into metallic solid (e.g., Cd2+ + 2e- ◊ Cd(s) and Cr3+ + 3e- ◊ Cr(s)) Thus, MECs can be used to remove toxic heavy metals from wastewater and simultaneously treat the wastewater and recover energy in the form of hydrogen gas. In lab-scale experiments, high removal rates for both cadmium and chromium (approximately 90% and 70% over 3 days, respectively) were demonstrated using a single chamber MEC with an applied voltage of 0.6 V. A kinetic model for the metal removal will be established and included in the presentation.

* Presenting author, colantn@mcmaster.ca

The Recovery of Silver Ions through the Operation of Microbial Electrolysis Cells

J. PARR [1*], Y. KIM [1]

[1]*Department of Civil Engineering, McMaster University*

Silver is a valuable material found in various types of wastewater. Effective removal of silver should not only reduce the impurities of treated wastewater, but also lead to the recovery and possible reuse of the high-value metal. One challenge of silver recovery from wastewater is the low concentration. Also, available treatment methods, such as membrane technology, cannot separate silver selectively from wastewater, making it practically impossible for silver recovery. Microbial electrolysis cells (MECs) consist of a bioanode and cathode, between which a small voltage is applied. Oxidation of organic contaminants occurs at the bioanode by exoelectrogenic microorganisms while reduction reactions are driven at the cathode, such as the reduction of water into hydrogen gas. With the electrode reactions in MECs we not only treat wastewater but also recover hydrogen gas. In addition to the water reduction reaction at the MEC cathode, silver ions can also be reduced to metallic silver (Ag+ + e- ◊ Ag) at specific cathode potential conditions, allowing direct silver recovery from wastewater. In this experimental study, MECs were used to recover silver from synthetic wastewater. To investigate the kinetics of silver recovery, the silver concentration in MEC reactors were analyzed using inductively coupled plasma-optical emission spectrometry (ICP-OES). Approximately 80% of the influent silver concentration was removed by the cathode reaction during each fed-batch cycle. Linear sweep voltammetry (LSV) tests were also conducted to investigate the effect of silver complex formation with common wastewater anions (phosphate, carbonate, nitrate and chloride) on the silver recovery on the cathode.

[*] Presenting author, parrjm@mcmaster.ca

Improving Secondary Effluent Quality for Water Reuse by Biological Filtration

S. ALY [1*], W. ANDERSON [1], P. HUCK [1], K. JASZCZYSZYN [2], S. KOLASKA [2]

[1]*Department of Civil & Environmental Engineering, University of Waterloo, Waterloo, ON, Canada N2L 3G1*
[2]*Poznan University of Technology, Institute of Environmental Engineering, Berdychowo 4, 60-965 Poznan, Poland*

While biological treatment processes are capable of substantial removal of organics found in wastewater, reusing secondary effluent for potable or nonpotable applications without advanced treatment is not recommended. As such, membranes are often used to further treat these effluents for water reuse. In this study, aerobic biofilters typically used in drinking water treatment were investigated for improving the characteristics of Waterloo Wastewater Treatment Plant treated secondary effluent for reuse. Two biofilters, one containing sand and the other containing anthracite, were operated under identical conditions. To quantify the organic compound fractions found in secondary effluent, Liquid Chromatography-Organic Carbon Detection (LC-OCD) analyses were performed in the influents and effluents of the sand and anthracite biofilters. Data revealed that both biofilters reduced dissolved organic carbon (DOC), especially the high molecular weight biopolymer fraction which was reduced by 25-30%. However, the biopolymer concentrations in the biofiltered secondary effluent were somewhat higher than in river and lake water sources and as such the biopolymer levels in the biofilter effluents were higher than would typically be seen using those sources. The higher removals of different DOC fractions achieved by sand appear to be attributable to the increased amount of attached biomass measured as ATP. Physical properties of secondary effluent were also improved after biofiltration, with a 90% reduction in turbidity in each of the biofilters. This study demonstrates that biofiltration can, under certain conditions, remove some treated wastewater constituents which have been associated with membrane fouling, and negatively affect other advanced treatments for water reuse.

[*] Presenting author, saly@uwaterloo.ca

Degradation of Polyvinyl Alcohol aqueous solutions in a continuous photoreactors

D. HAMAD [1*], M. MEHRVAR [1], R. DHIB [1]

[1] *Ryerson University*

Polyvinyl alcohol (PVA), a dominant contributor of total organic carbon (TOC) in textile wastewater, is not easily degradable by conventional methods of wastewater. This study investigates the reduction of TOC and molecular weight of aqueous PVA solution in a continuous UV/H2O2 photoreactor operated in a continuous mode. A recent study by our research group showed that the feeding strategy of hydrogen peroxide can have a considerable effect on the degradation of PVA under UV light. Response surface methodology involving the Box-Behnken method is adopted to design a set of experiments in order to provide an understanding of the impact of operation variables on the process performance. The study investigates the main operating parameters affecting the PVA degradation including PVA inlet concentration, hydrogen peroxide inlet concentration, and the feed flow rate of the wastewater. The TOC removal in continuous mode ranged from 16.1% to 41.7% while the molecular weight reduction ranged from 56.29 up to 6.11 kg/mol. The inlet concentrations of PVA (with molecular weight of 130 kg/mol) are 500, 1000 and 1500 mg/L with the residence time of 6.1 up to 18.4 min at different hydrogen peroxide concentrations. The results also prove that the continuous feed of proper amount of hydrogen peroxide is required to improve the degradation of PVA, however, further increase of hydrogen peroxide concentration might inhibit the system efficiency. Optimum operating conditions to maximize the percent TOC removal and minimize polymer molecular weight and hydrogen peroxide residual have been determined.

* Presenting author, dhamad@ryerson.ca

TiO2 nanocrystalline films and membranes for concurrent photocatalytic organic degradation and corrosion protection

R. LIANG [1*], M. HATAT [1], M. ARLOS [1], P. PENG [1], M. SERVOS [1], N. ZHOU [1]

[1] *University of Waterloo*

Organic contaminants and corrosion in water treatment effluents are a current and emerging global problem and the development of effective methods to facilitate the removal of organic contaminants and corrosion control strategies are required to mitigate this problem. TiO2 nanomaterials that are exposed to UV light can generate electron-hole pairs, which undergo redox reactions to produce hydroxyl radicals from adsorbed molecular oxygen. They hydroxyl radicals are able to oxidize organic contaminants in water. This same process can be used in conjunction to protect metals from corrosion via cathodic polarization. In this work, TiO2 nanomaterials were synthesized and deposited on conductive substrates to serve as films or membranes via electrophoresis. An illuminated TiO2 film on a conductive surface served as the photoanode and assisted in the cathodic protection of stainless steel (SS304) and the degradation of organic pollutants, in this case glucose. This proof-of-concept relied on photoelectrochemical experiments conducted using a potentiostat and a xenon lamp illumination source. The open-circuit potential changes that determine whether a metal is protected from corrosion under illumination was observed; and the electrical characteristics of the TiO2 film or membrane under dark and arc lamp illumination conditions were also analyzed. Furthermore, the effect of organic contaminants on the photocathodic protection mechanism and the oxidation of glucose during this process were explored.

[*] Presenting author, rliang@uwaterloo.ca

Pure and doped photocatalytic membranes for organic pollutants removal

M. HATAT-FRAILE [1*], P. RUSSO [2], R. HE [1], R. LIANG [1], N. ZHOU [1]

[1] *University of Waterloo*
[2] *University of waterloo*

Pure and doped photocatalytic membranes for organic pollutants removal Mélisa HATAT-FRAILE, Paola RUSSO, Rui Xiu HE, Robert LIANG, Y. Norman ZHOU Centre for Advanced Materials Joining, Department of Mechanical and Mechatronics Engineering, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, Canada Titanium dioxide (TiO2) is known as the most used and the most efficient photocatalyst for the degradation of persistent organic pollutants present in water. In this study, pure, doped and co-doped nano-coatings were prepared from chemically active TiO2 colloids. These colloids are generated in sol-gel reactor with rapid turbulent micro-mixing. Two alcoholic solutions (titanium tetra iso-propoxide precursor and water with two dopants: urea and boric acid) were mixed using a T mixer. Thin nano-coatings were synthetized by dip-coating quartz fiber filters in this mixture. All materials were characterized by XRD, XPS, band-gap observations, SEM observations… Photocatalytic filtrations were performed in dead-end photocatalytic membrane reactor under UV irradiation (254 and 365 nm). Depending on the TiO2 thin film used, variations of filter wettability and flux were observed under irradiation. For photocatalytic experiments, acid orange 7 was used as a model pollutant. Dye was not completely degraded. B-doped TiO2 offered the best degradation rate with both irradiation sources. 20% of degradation was obtained with only one crossing through composite membrane (contact time estimated as several milliseconds).

* Presenting author, mhatat@uwaterloo.ca

An overview of options for humanitarian emergency sanitation

J. LAURENS [1*], P. A. VANROLLEGHEM [1], C. C. DOREA [1]

[1] *Université Laval*

Adequate sanitation facilities are seriously lacking in developing countries. This problem is further compounded in humanitarian emergencies. Under these circumstances, resources are limited and affected populations are left vulnerable to diarrheal diseases. The most common sanitation interventions in emergencies are pit latrines. Their main issue occurs when they are full and must be emptied. In general, the pit contents are dumped in the environment without any treatment and cause public health and environmental threats that the latrines are meant to prevent. Therefore, the treatment of human waste from pit latrines is warranted. Our aim here is to present an overview of existing possibilities that can be adapted for the treatment (i.e. disinfection and possible biological stabilization) of human waste for humanitarian emergencies. Based on existing literature two options are available: physicochemical and biological treatment. A treatment system suitable to emergency situations needs to be low-cost, simple and an operationally easy process to be designed into a treatment "kit". By its nature biological treatment requires time to develop and become efficient, and can therefore not be suitable for emergency situations. On the other hand, several chemical reagents are available, but not all have been tested for emergencies. Chlorine and lime are already used in humanitarian contexts because they readily accessible and of relative low-cost. Both can eliminate pathogens and reduce fecal sludge odor. However, a standardized procedure for its application is still lacking. Potassium ferrate has not been used yet in emergency situations, but its oxidation/disinfection and solids reduction (i.e. coagulation) effectiveness over a wide pH range makes it an interesting candidate. Furthermore, organic compounds can also sanitize human excreta, namely: ammonia (naturally available from urea) or lactic acid produced by some bacteria. A critical evaluation of these options based on technical and operational consideration points to potentially viable solutions to a pressing problem faced in humanitarian emergencies.

[*] Presenting author, jean-matthieu.laurens.1@ulaval.ca

Solar Photocatalysis with Nanostructured Titanium Dioxide (TiO2) Materials for the Inactivation of E. coli Bacteria

S. GORA [1*], S. ANDREWS [1]

[1] *University of Toronto*

Solar photocatalysis (solar/TiO2) with TiO2 nanoparticles is a promising process for drinking water disinfection but it has yet to be widely applied at the full scale, partly because it has proven difficult to design a reactor that ensures adequate treatment efficiency without allowing any of the nanoparticles, which are approximately 20 nm in diameter, to travel through to the finished water. One solution to this is the development and application of larger nanostructured TiO2 materials such as nanotubes and nanobelts that are easily removed from the water through sedimentation or filtration. TiO2 nanotubes and nanobelts were synthesized from standard Aeroxide P25 nanoparticles from Evonik using a hydrothermal method. The materials were characterized using scanning electron microscopy (SEM), x-ray diffraction (XRD), and by their ability to degrade two indicator dyes, methylene blue and acid orange 24. Experiments are currently being conducted to determine how well the lab synthesized materials compare to standard TiO2 nanoparticles for the inactivation of E. coli bacteria. The inactivation experiments are being conducted with 0.05 g/L of TiO2, simulated solar light, and an initial E. coli concentration of 10^6 CFU/mL. Results to date indicate that the nanotubes are nearly as effective as the standard nanoparticles for E. coli inactivation. Both materials achieved over 5 log reduction of E. coli after 10 minutes of irradiation. TiO2 alone did not inactivate E. coli but 10 minutes of simulated solar irradiation resulted in 0.5 log reduction, suggesting that both irradiation and photocatalytic oxidation contribute to E.coli inactivation during solar/TiO2 treatment.

[*] Presenting author, stephanie.gora@mail.utoronto.ca

Pilot-Plant Study for Sonophotolytic Degradation of Synthetic Pharmaceutical Wastewater

S. GHAFOOIR [1*], M. MEHRVAR [2], P. CHAN [3]

[1] *Australian College of Kuwait*
[2] *Department of Chemical Engineering, Ryerson University*
[3] *Department of Chemical Engineering, Ryerson University*

Sonophotolytic degradation of a synthetic pharmaceutical wastewater is investigated in a pilot-scale external loop airlift reactor. In the first part of this study, multivariate experimental design is carried out using Box-Behnken design. The effluent is characterized by the total organic carbon (TOC) percent as a surrogate parameter. The statistical analysis of the results indicates a satisfactory prediction of the system behavior by the developed model. In the second part of this study, a novel rigorous mathematical model for the sonophotolytic process is developed to predict the TOC percent removal as a function of time. The mathematical model is based on extensively accepted sonophotochemical reactions and the rate constants in advanced oxidation processes. A good agreement between the model predictions and experimental data indicates that the proposed model could successfully describe the degradation of the pharmaceutical wastewater using sonophotolysis process.

[*] Presenting author, samira.ghafoori@gmail.com

Wastewater Nutrients Removal and Recovery by Combining Struvite Precipitation with UniBAR-Anammox Process

S. KALAM [1*], D. MAVINIC [1], B. REZANIA [2]

[1]*Department of Civil Engineering, The University of British Columbia, Vancouver, BC*
[2]*Prongineer Ltd., Vancouver, BC*

Nitrogen and phosphorus from municipal and industrial wastewater discharges are the primary causes of eutrophication within surface waters causing depletion of desirable flora and fauna, low dissolved oxygen and endangering aquatic life. Technologies like Struvite precipitation for P-recovery and ANAMMOX for N-removal both are established and result driven methods to manage one nutrient at a time. Combining these two processes is expected to remove over 80% of Phosphate and ammonia-Nitrogen from the dewatered sludge or centrate. The main challenge lies in the fact that Struvite precipitation is a very quick chemical process whereas Anammox is a slow biological process. A pilot scale study was conducted at Annacis Wastewater Treatment Plant Research Center Combining Struvite precipitation process using UBC Struvite Crystallizer followed by UniBAR-Anammox process. Baseline studies of these two separate processes have shown over 80% and 70% of P and N removal respectively. Challenges in combining the Anammox process post-Struvite crystallizer were the effects of chemical (Caustic and Magnesium Chloride) addition in the Struvite process and the produced Struvite fines on the Anammox process. Three months continuous operation of this combined process successfully removed 89% of phosphorus from the wastewater which was also recovered as nice round Struvite pellets which is a slow releasing fertilizer with commercial values. Average N-removal of more than 70% before and after combination indicated a successful process combination without adverse effect of chemical addition.

* Presenting author, sifat390@civil.ubc.ca

Biotransformation of Trimethoprim in Biological Nutrient Removal Treatment System – The Role of Active Microbial Groups

O. OGUNLAJA [1*], W. PARKER [1]

[1] *University of Waterloo*

A pilot scale biological nutrient removal (BNR) process, batch experiments and modeling exercises were employed to investigate the removal and biotransformation of trimethoprim (TMP) in a BNR activated sludge. The concentrations of the active microbial groups- ammonia oxidizing bacteria (AOB), ordinary heterotrophic organism (OHO) and polyphosphate accumulating organism (PAO) in the BNR bioreactor were quantified through modeling of the pilot bioreactor. The TMP biotransformation efficiencies in the anaerobic, anoxic and aerobic sections were 13 ± 12%, 17 ± 10 % and 24 ± 4% respectively. Batch tests with and without nitrification inhibition showed that AOB played a role in the biotransformation of TMP in BNR activated sludge. A pseudo first order model that incorporated the contributions of PAO, OHO and AOB to the overall biodegradation of TMP was found to describe the biodegradation of TMP in batch tests with and without nitrification inhibition. The estimated biotransformation rate constant with respect to PAO, OHO and AOB were 0.32 ± 0.06, 0.58 ± 0.06 and 13.7 ± 0.06 L/gCOD/d respectively. This model showed that PAOs, OHOs and AOBs contributed towards the biotransformation of TMP in BNR activated sludge with the trend AOBs = PAOs > OHOs.

[*] Presenting author, oogunlaj@uwaterloo.ca

ADVANCES IN DRINKING WATER AND STORMWATER TREATMENT TECHNOLOGIES AND APPROACHES

Decision making tool for the establishment of adapting measurement of urbain drainage system to the climate change

N. MHAMDI [1*], S. KOUKI [2], S. DUCHESNE [3], M. FUAMBA [1], A. SEBTI [1]

[1]*Ecole polytechnique de Montreal*
[2]*Laval university*
[3]*INRS-ETE*

Variability in rainwater flows directly affects the behavior of drainage infrastructure in urban areas , in fact, it still one of the main factors wich affect the quality of service that drainage infrastructure can guarantee . The surcharges , water discharge and / or floods in combined sewer systems are the result of a decrease in the level of network performance . The existing and future drainage systems, specifically the combined sewer system must be adapted to the problems of climate change to meet the objectives of their facility's discharge of Storm water and combined sewer overflows (CSO). To cope with the problem of combined sewer surcharge, studies have been made to find solutions to this problem. These solutions include the use of best management practices BMP (BMP are standard measures for the management of stormwater and wastewater whether in urban or rural areas) . These practices are numerous and varied depending on the context and the expected objectives. The main objective of this work is to develop a decision making tool (Matlab program) that may help the sewer manager deciding wich BMP should install. To achieve this objective, we (1) Determine the performance criteria of existing infrastructure that can be affected by the impacts of climate change, (2) determine the terms of the hydrological cycle, including future precipitation in the study area in the context of climate change, (3) Determine adaptation measures of drainage infrastructure to the impacts of climate change (CC), (4) Develop a decision making tool that helps sewers system managers to make the right decision with respect to the standards of the Canadian strategy. This approach was tested on a case study in “Quebec city” and the results obtained showed that the model seems efficient in choosing the Best Management practice for each basin versant

[*] Presenting author, mhamdi_nejib@yahoo.fr

Determination of N-nitrosodimethylamine (NDMA) Compounds in Chloraminated Drinking Water

V. Zhao

Drinking Water Research Group
Department of Civil Engineering
University of Toronto
Toronto, ON M5S 1A4

N-nitrosodimethylamine (NDMA) is a member of the nitrosamine family of disinfection by-products recently found in chloraminated drinking water. It is of potential concern because NDMA at ng/L levels can contribute to a high cancer risk.

Nitrosamine FP and FK of seven compounds in pH-buffered ultrapure water have been determined. These seven compounds are tertiary amines with structures that suggest they could be potential nitrosamine precursors. Also, they are frequently used in commercial products and are likely to occur in drinking water supplies.

Test results confirmed that high NDMA yields from Nizatidine and N,N-Dimethylbenzylamine (DMBzA) could be attributed to the presence of a single carbon atom between the aromatic ring and the DMA structure. When there wasn't just one carbon between the aromatic ring and DMA structure (i.e. none, two carbons or more), low yields were obtained. This was demonstrated by the other five compounds. In addition, the reaction rate was found not to be related to the yields, and the nitrosamine yield results for O-Desmethylvenlafaxine and Hordenine are reported for the first time in this study.

Chlorine residuals were also measured during the kinetics tests. All the parameters, including total chlorine, monochloramine, and pH values were shown to be very stable, with monochloramine concentrations well above 90 % of the total chlorine values. Based on comparisons of test samples with control samples, the decrease of chlorine residual likely did not come from reactions with the low concentrations of precursors but from slow autodecomposition.

Considerations for the Removal, Treatment and Fate of Stormwater Management Pond Sediments

P. KOUMOULAS [1*], D. JOKSIMOVIC [2]

[1]*Ryerson University*
[2]*Ryseron University*

Stormwater management (SWM) ponds are a widely used option to control runoff, decrease flooding potential, reduce erosion rates in receiving waters and improve water quality. In the Greater Toronto Area (GTA), there is an estimated 1500 SWM ponds, with many more slated for construction. For all of these ponds, sediment maintenance is required to maintain pond efficiency; however, clean-out costs are quite expensive and only an estimated 1% of ponds in the GTA have received clean-out. The most commonly used clean-out options are sediment removal by dredging and disposal to an appropriate facility based on sediment quality. However, there is a need to consider alternative sediment removal and remedial options as well as potential beneficial uses, since 1) overall costs for a single pond can be substantial and 2) a large number of ponds are approaching their operational capacity. It is evident that numerous remedial options, specifically biological and physical treatment methods, can be utilized to not only improve sediment quality, but also promote its future reuse in agricultural settings, construction materials, fill within road substrate and shoreline projects, compost, or as daily fill within registered landfills. The intent of the current research was to develop guidance for municipalities and operators when faced with contaminated stormwater sediments. This paper presents a review of potential removal, treatment, disposal and beneficial use options and offers a simple decision support methodology to aid in the selection of options. The creation of a central database, complementing the decision support tool, is suggested to systematically track SWM pond maintenance activities in Ontario, providing information that can be used for further inform the decision making process, and aid in establishing more accurate SWM pond sediment accumulation methods.

* Presenting author, panagiotis.koumoulas@ryerson.ca

Conductive Ultrafiltration Membrane Fabrication via a Novel Vacuum-Assisted Layer-by-Layer Assembly of Functionalized Carbon Nanotubes

F. OMI [1*], S. RAHAMAN [2]

[1]*MASc. Student, Building, Civil and Environmental Engineering, Concordia University*
[2]*Assistant Professor*

Membrane processes are currently used in several ways to purify water and wastewater. Because of their high performance and smaller footprint, membranes are likely to grow in importance as compared to other conventional technologies. Therefore, there is a critical need for development of improved membranes that have higher flux, greater selectivity, and are less prone to fouling. Recently, multiwalled carbon nanotube (MWNT) electrochemical (EC) filter was reported to be extremely effective as a point-of-use technology in achieving complete removal and inactivation of pathogens. In order to scale-up the electrochemical filtration technology to utilize it in a plant-scale centralized water treatment plant, conductive nano-composite ultrafiltration membranes were developed in this project, through incorporating amine and carboxylic functionalized MWNTs (MWNT-NH2, MWNT-COOH) into polysulfone (PSf) substrates. A novel fabrication method, vacuum-assisted layer-by-layer self-assembly was used for surface modification of polysulfone ultrafiltration membrane. The MWNT modified PSf membrane was characterized with SEM that showed the uniform distribution of MWNTs throughout the membrane thickness as well as a linear growth in membrane thickness with increasing number of MWNT bilayers. The modified membrane exhibited reasonable permeability, higher conductivity and high antifouling properties due to application of very low DC potential (0V-3V). Due to high conductivity of the MWNT modified membrane an application of 3V DC voltage showed almost 100% inactivation of E. coli inactivation suggesting the effectiveness of the MWNT modified polysulfone membrane in controlling the biofouling in electrofiltration system. Moreover, this study showed over 99% degradation of methyl orange during electrofiltration that could contribute to reducing the organic fouling of the modified membrane. Overall, the new MWNT modified polysulfone membrane has huge potential to be used in large scale electrofiltration systems.

[*] Presenting author, farahomi@gmail.com

ENVIRONMENTAL MONITORING AND MODELING

Food Waste Characteristics And Implications For Resource Recovery At Wastewater Treatment

M. KIM,[1] M. M. I. CHOWDHURY[2], G. NAKHLA[1,2], M. KELEMAN[3]

[1]Chemical and Biochemical Engineering, the University of Western Ontario, London, ON, Canada N6A 5B9
[2]Civil and Environmental Engineering, the University of Western Ontario, London, ON, Canada N6A 5B9
[3]InSinkErator, Emerson Commercial & Residential Solutions, 4700 21st Street, Racine, WI 53406-5031

A pressing concern in fast growing population and urbanization is effective food wastes (FW) management. Traditionally, FW are disposed to the landfills; however, diverse negative issues have arisen such as shortage of landfill sites and environmental contamination by leachate. One alternative way to reduce FW disposal to landfills is the use of FW disposers (FWD). FWD is an electric grinding device installed under the sink. FW that is grinded with tap water is discharged to the sewer system that leads to sewage treatment plants (STP). This technology has been used in many countries; the United States showed the highest market penetration rate (50%). However, concerns exist due to potential negative effects of this method on the sewer system such as organic loading increase and wastewater characteristic change. In order to study potential effects of FW characteristics on STP, detailed characterization of FW using typical US food composition were conducted to analyze different constituents in particulate and soluble forms. Results showed that one gram of dry FW generated 1.21 g chemical oxygen demand (COD), 0.58 g biological oxygen demand, 0.36 g suspended solids, 0.025 g nitrogen, and 0.013 g phosphorus. Additionally, 40% of COD and 30% of nitrogen were present in soluble phase. COD/nitrogen ratios were higher in soluble form that particulates (63:1 versus 42:1). Results indicate that FW can be used as a beneficial carbon source to enhance biological nutrient removal in STP. Moreover, enriched particulate nutrients of FW can also improve the quality of biosolids.

* mkim286@uwo.ca

Economic evaluation of anaerobic digestion of dairy waste at Athlone Farm

Dana Baer, Aryn Cain, Jennifer Chan, Paul Chiocchio, Elyse Dickson, Ann Gibson, Matthew Iannetta, Jessica MacKinnon, Elsayed Elbeshbishy*

University of Waterloo, Waterloo, Ontario, Canada, N2L 3G1

An economic evaluation of the anaerobic digester at Athlone Farms (near Stratford, Ontario) was evaluated. The Athlone Farms is a dairy and cash crop farming operation, running 600 acres of land with 300 head of cattle. The anaerobic digester with volume of 2,180 m^3 was fed with composed of food waste supplied from local businesses, liquid and dry dairy manure produced on farm, and chicken manure from a neighboring farm. The methane production rate of 104 m^3/hr and volatile solids reduction (VSR) of 38% were achieved at a solid retention time (SRT) of 25 days. Athlone Farms digester generates 2,520 MWh per year which is equivalent to an emission avoidance of 16,000 tonnes of CO_2 per year. An economic analysis of the digester determined the payback period of the operation to be nine years. Overall it can be concluded that anaerobic digesters lower greenhouse gas emission levels and are economically feasible for farms to invest in.

Integrating watershed modelling with socioeconomic values in Lake Simcoe

Gudimov A., Kim D-K and G.B. Arhonditsis

University of Toronto

Lake Simcoe ecosystem integrity depends on the mitigation of non-point phosphorous sources. Tributary flows from adjacent watersheds represent a significant portion of the total loading (70-80 MT P/year), which can be controlled by the effective implementation of Best Management Practices in agriculture and storm water management. Building the foundation for a SWAT modelling exercise, our aim is to provide an integrated assessment of the environmental challenges and socioeconomic values in Lake Simcoe watershed. Using artificial neural network techniques, we classified 284 subwatersheds based on their soils characteristics, land use types, P export coefficients, and socio-economic parameters from the 2006 Census data. Our analyses renders support to the hypothesis that the expected shift from low to high density urban areas along with the concurrent urban sprawl from South to North may represent a major challenge for controlling tributary loading and consequently improving the tropic status of Lake Simcoe. Social media in Twitter and Google indicate different emotional bonding with the lake for residents of existing highly urbanized areas compared to low population areas, which may require special consideration when implementing programs of stewardship and forming general public acceptance of environmental policies.

Evaluation of Stormwater Quality Impact due to Construction Activities in the Lake Simcoe Watershed

J. LI [1*]
[1]*Ryerson University*

Exposed soil surfaces are eroded by wind and rain water resulting in transport of phosphorus to receiving water bodies. Rain water can also erode a few millimeters of top soil at construction sites per construction season. As a result, rain erosion associated with construction activities should be controlled in order to manage phosphorus loading to Lake Simcoe. Gharabaghi (2012) identified and estimated the atmospheric dry and wet deposition of nutrients to Lake Simcoe and recommend a range of best management practices (BMP) for the management and control of atmospheric sources of phosphorus to Lake Simcoe. This presentation focuses on the rain water erosion from construction sites and the associated best management practices. It will (1) review measures to reduce the transport of phosphorus from a construction development site including erosion and sediment control BMPs and regulatory controls associated with construction activities; (2) Evaluate the effectiveness of measures to reduce transport of phosphorus from a construction development site including BMPs and regulatory controls; (3) Estimate average phosphorus removal efficiencies of BMPs; and (4) Identify preferred measures to reduce the transport of phosphorus from a construction development site that could be included in construction site plans.

* Presenting author, jyli@ryerson.ca

Lake Superior nearshore water quality: 1980-2013

M. PALMER [1*], J. WINTER [1]

[1]*Ontario Ministry of the Environment and Climate Change*

Lake Superior is the largest lake by surface area in the world and contains almost 10% of Earth's liquid freshwater. Its large size and relatively small watershed with sparse human population and limited land use have protected Lake Superior from the dramatic human impacts observed in the lower Great Lakes. Consequently, Lake Superior is the most pristine of the Great Lakes. However, Lake Superior is not immune to anthropogenic influences and stressors such as climate change, chemical contaminants, invasive species and development have caused ecological change. The Ontario Ministry of the Environment and Climate Change has been monitoring water quality and phytoplankton in the nearshore of Lake Superior since the 1980s. Untreated water samples are collected weekly from intake pipes at municipal water treatment plants in Thunder Bay and Terrace Bay along the northshore of the lake. Weekly samples are analyzed for nutrients, chloride and chlorophyll. Monthly composite samples are analyzed for phytoplankton. In this presentation, we (1) characterize and compare water chemistry and phytoplankton communities at the monitoring locations; (2) report 34-year trends in water quality; (3) investigate seasonal patterns in phytoplankton; and (4) identify relationships between water chemistry and phytoplankton.

* Presenting author, michelle.palmer@ontario.ca

Understanding phosphorus patterns and calculating loads in tributaries of the Lake Simcoe watershed: the use of in-situ turbidity measurements as surrogate for phosphorus.

E. O'CONNOR [1*], L. ASPDEN [2], D. LEMBCKE [3]

[1]*Lake Simcoe Region Conservation Authority*
[2]*Lake Simcoe Region Conservation Authority, Watershed Management, Environmental Science and Monitoring,*
[3]*Lake Simcoe Region Conservation Authority, Watershed Management, Environmental Science and Monitoring*

The accurate calculation of phosphorus loads to lakes is critical for making management decisions concerning their ecological health and sustainability. Tributaries supply a large portion of the total load to Lake Simcoe and are a function of flow and concentration across time. Flow is measured continuously at a reasonable cost whereas concentrations are derived from discrete sampling (biweekly, for example). Models are typically used to estimate loads for the period between samples, but their success across a large watershed is limited due to variation of phosphorus behaviour in different river systems. The purpose of this study is to evaluate the suitability of using turbidity as a surrogate for phosphorus. Turbidity can be highly related to phosphorus ($r > 0.9$) in river water and can be measured continuously using in-situ sensors. Turbidity data could be used to increase understanding of phosphorus patterns. Accurate loadings may be attained for periods between samples using their relationship. This would be especially useful for different types of river systems that have varying phosphorus behaviour (according to the hydrograph, for example). Continuous monitoring of turbidity was accomplished using probes placed in four river systems of varying landuse (urban, agricultural and natural) in the Lake Simcoe watershed. Daily, or subdaily, water quality samples (for phosphorus) were available for a portion of the time period, but otherwise samples were collected on a biweekly and episodic event basis via the routine monitoring program. Continuous flow data was available also. Challenges with in-situ turbidity measurements and data quality control will be outlined. Ultimately, greater understanding will be acquired regarding hydrochemical behaviour, and this knowledge could lead to application of the method in other tributaries of Lake Simcoe. This would strengthen the monitoring program of the watershed by providing superior water quality trend analysis and load quantification.

[*] Presenting author, e.oconnor@lsrca.on.ca

Monitoring phytoplankton densities and nutrient concentrations in the nearshore waters of Lake Erie since the 1970s

J. WINTER [1*], M. PALMER [2], T. HOWELL [2], J. YOUNG [2]

[1]*Ontario Ministry of the Environment and Climate Change*
[2]*Ontario Ministry of the Environment and Climate Change*

Monitoring at five municipal water treatment plant intakes on Lake Erie revealed several significant trends in nearshore nutrient concentrations and phytoplankton since the 1960s and 1970s. Phytoplankton densities, in particular the abundance of diatoms, decreased following early phosphorus loading controls and the establishment of dreissenid mussels. There were notable reductions and breakpoints in the trends in phytoplankton cell densities in consecutive years from the west to the east in the lake (in the western basin in 1987, central in 1988, and eastern in 1989) coinciding with the timing of dreissenid mussel invasion and establishment. There have also been shifts in phytoplankton species composition that were related to variations in total phosphorus, chloride, silica, and nitrate concentrations. Annual mean phosphorus concentrations have decreased significantly and remained low since the early 1990s in the eastern basin, showed no consistent trend in the central basin, and decreased in the western basin. Concentrations have increased in the western basin since the mid-1990s, although not to the levels seen during the early 1980s. Recently, chlorophyll a concentrations have also increased in the western and eastern basins of the lake.

[*] Presenting author, jennifer.winter@ontario.ca