

NSERC – Industry Project on Metal Bioavailability Research Newsletter



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Wilfrid Laurier & McMaster University

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NEWS

The aim of this newsletter is to report on people and the projects they are working on. The star & scholar of this newsletter edition is **Rabi Nasir**, from Jim McGeer's lab, who will be sharing some of her M.Sc. work, entitled "Interactive Effects of Salinity and Dissolved Organic Matter on Cu Toxicity to *Americamysis bahia*", much obliged!

Comings and goings (Nov. 2012 – Nov. 2013):

In the Super-duper Smith lab it's all change. **Giselle Cimprich** and **Scott Holmes** spent this last academic year on rotifer toxicity testing during their undergraduate honours research projects (co-supervised by Jim McGeer). Giselle has now moved to Ottawa to get married, whereas Scott H is (hopefully) off to be weatherman, well study meteorology, close enough. Good luck to both of them. **Tara Tait** successfully defended her M.Sc. ("Determination of Copper Speciation, Bioavailability and Toxicity in Saltwater Environments") and was even nominated for a gold medal! Great work Tara! Tara is now an environmental toxicologist at 'Exp Services Inc'. **Maya Ashoka** was an NSERC USRA summer student working with McGeer and Smith on fluorescence methods to investigate rare earth element speciation. **James Vey** is a new M.Sc. student in Smith's lab working on computational and experimental aspects of Ni speciation in saltwater systems. James is co-supervised by **Ian Hamilton** in the Chemistry Department at Laurier. **Gaganprit Gill** is currently an undergraduate student who is building and testing Ni ion selective electrodes. **Michelle Nguyen** is continuing the work with cupric ISE at variable pH in saltwater samples that **Bob** and **Bobby Santore** started during their summer "chemcation" (a summer vacation where you do experiments in a chemistry

lab! [I didn't come up with that one – Scott did]). This summer Smith's lab also had a visit from **Lara Settimio** a Ph.D. candidate from **Mike Mclaughlin's** group at CSIRO in Australia. Lara came to learn fluorescence measurement and data processing techniques to characterize DOM. There was a third visitor this summer when **Weibin (Ben) Chen**, Scott's co-supervise Ph.D. student (with **Céline Guéguen**) came from Trent University to setup AGNES, a free Zn measurement technique Ben learned from **Josep Galceren** in Spain. Also, a quick shout out to Scott Smith who got his 5 minutes of fame. His lecture was replayed on local cable TV: Research driven by regulatory needs: metals and nutrients in aquatic systems. Milton Laurier Lecture Series, January 2013. Milton, ON, Canada. Join the back of the queue for autographs...

In the Marvelous McGeer lab **Kelly Livingstone**, **Katherine Chan**, **John Ellis** and **Emily-Jane Costa** have all recently completed their M.Sc. degrees. Kelly is currently working in the Smith lab while Emily Jane, whose thesis was awarded the Laurier Gold Medal and also the Aquatic Toxicity Workshop's Richard Playle Award for Outstanding Thesis, is working for Golder Associates in Vancouver. **Oliver Vukov**, **Che Lu** (M.Sc.'s) and **Alyssa Verdin** (honours thesis) are working on understanding toxicity modifying factors interactions on lanthanide toxicity (Ce, Dy and Sm currently) to different strains of *Hyalella azteca*. **James Duncan** (honours thesis) is developing test methods (using Cu) for the estuarine hydroid *Eudendrium carneum* based on tentacle regression while **Rabia Nasir** has been studying how salinity and organic matter modulate Cu toxicity to *Americamysis bahia*. On the fish side of things **Tyler Weinhardt**

(M.Sc.) is working on the sublethal effects of suspended material on trout in the context of permafrost thaw and massive slumps on the Peel Plateau in northern Canada. **Amy Clement** (honours thesis) and **Wesley Truong** (M.Sc.) are also looking at sublethals impacts in trout but their research is related to metal mixtures. The newest M.Sc. student, **Prachi Deshpande**, is also working on mixtures but with daphnids in very soft waters.

One of the more notable events this summer was the training workshop with Environment Canada on June 20th. The day long workshop, developed by Jim and Scott on invitation from Environment Canada covered the role of dissolved organic matter on environmental behaviour of metals. Approximately 25 staff from Existing Substances, New Substances, Emerging Priorities and the National Guidelines and Standards Office participated in discussions. Seven presentations (see presentation section below) on DOC-metal interactions were delivered by Jim, Scott, Kelly Livingstone and Erik Szkokan Emilson (Ph.D. student from the John Gunn lab at Laurentian University).

In the Wonderful Wood lab, former M.Sc. student **Margaret Tellis** returned in January, and she has been working with Kevin Brix (Jan-Sep) generating preliminary data on radioisotopic binding of metals to trout gills. Welcome back Margaret! In addition, Margaret is to **Adalto Bianchini**'s lab at the Federal University of Rio Grande (FURG) in southern Brazil, as part of the IDRC-CRC International Research Chair exchange program, from Oct. 22 to Dec. 17 to undertake field research determining whether DOC protects against the toxic effect of Cu, Zn and Pb in the larvae of sea urchin *Strongylocentrotus purpuratus*. **Kevin Brix** has been awarded a 2-year NSF Post-Doctoral Fellowship to study Na⁺ and Ca²⁺ regulation in marine and freshwater stickleback populations and use QTL techniques to identify genetic loci important in the adaptation of fish to freshwater. He has left McMaster and started the new PDF at University of British Columbia from September.

We thank him for his great contributions to the metal work in our lab. Kevin will continue to be involved in collaborative metal projects, and is currently mentoring 4th year undergraduate project **Jerome Louie** at UBC in a project looking at chronic endpoints of multiple metal toxicity. Former Ph.D. student **Joel Klinck** has accepted a position as Assistant Professor at Redeemer University College in Hamilton, starting July 1, 2013. Congratulations Joel! Three undergraduate students, **Joanna Smich**, **Shaun Ng** and **Michael Lim** have recently joined our lab to start their 4th year thesis research projects. Their projects are mostly on basic fish physiology. Joanna and Shaun are mentored by our Masters students, **Julian Rubino** and **Mike Lawrence** respectively. Joanna is working on the ammonia handling in the gut of rainbow trout with the influence of amino acids and Shaun's project is on hormonal regulation of renal ammonia excretion in teleost fish. Michael is mentored by our Ph.D. student **Alex Zimmer**. Michael's project investigates the effects of Cu and ammonia on ammonia excretion and sodium uptake in fish. Greetings to **Dr. Rafael Duarte**, a postdoctoral fellow at INPA (The Amazon Research Institute in Manaus, Brazil) who is jointly supervised by Dr. Adalberto Val (Director of INPA) and Dr. Chris Wood, as part of the Brazilian "Science without Frontiers" program, is spending 5 weeks in Canada. During this period he is working with Scott Smith at Wilfrid Laurier and Chris Wood at McMaster, characterizing the physicochemical and optical properties of two "blackwater" DOC's extracted from the upper and lower reaches of the Rio Negro river, and examining their potential protective effects against the physiological toxicity of low pH and Cu exposure in zebrafish. Hope they all enjoy working in our lab! On a side note, **Tamzin Blewett** (Ph.D. student in Wood lab) joined a large team that went to Bamfield Marine Science Centre, B.C. this summer from mid-July to late August. She looked at the toxicity of Ni and Pb on the green crab, *Carcinus maenas*. She also collaborated with **Sandra Fehsenfeld** from University of Manitoba on investigating the

toxicity effect of Cu and 1 % CO₂ on the green crabs, with **Chris Glover**, from Canterbury University, Christchurch New Zealand, looking at Ni uptake in hagfish, and with **Som Niyogi**, University of Saskatchewan, looking at Zn uptake in green crabs.

In the Majestic McClelland lab, **Victoria Ransberry** successfully defended her M.Sc. research entitled "Oxidative stress and metabolic responses of acute water-borne copper exposure in killifish". She is now working for the consulting company Applied Aquatic Research in Calgary. **Narina Jabari** successfully completed her undergraduate thesis on the "Physiological effects of copper and hypoxia exposure in the common

Killifish, *Fundulus heteroclitus*, as measured through oxygen-dependent gene and protein expression". Narina worked this summer on hypoxia and Cu exposure in fish, and in Bamfield on Cu exposure in euryhaline crabs. **Sheridan Baker** has joined the lab as an undergraduate researcher to look at the effects of chronic Cu on acute stimulation of respiration in killifish. **Alex Connaty** (MSc) has been hired as a research technician to work on Cu toxicity in green crabs and mitochondrial effects of Cu in killifish.

New Funding:

- Scott and Jim are part of a team of 9 researchers at Laurier who have recently celebrated the finalization and delivery of two funding initiatives with the official opening of the Centre for Cold Regions and Water Science. The new building is 11,000 square feet and with the new equipment being installed is a \$13 million dollar investment in water research infrastructure at the University. The building opened October 11 and houses two initiatives: the Canadian Aquatic Laboratory for Boreal Ecosystem Research (CALIBER) and the Southern Ontario Watershed Consortium (SOWC).
- Chris Wood and Kevin Brix have received funding from a consortium of metal research organizations (IZA, NiPERA, ICA, CDA, and Rio Tinto), through IZA, for a three year research project entitled: "*Developing Experimental Data for a Multi-Metal BLM framework – Back to Basics*". The project will examine metal interactions at BLM binding sites using rainbow trout as an acute model, and freshwater snails as a chronic model.
- Jim and Scott were funded through the NSERC Strategic Grants program proposal: Bioavailability, toxicity, mobility and modeling of data poor metals (BIOMET). This project is led by Kevin Wilkinson (U. Montreal) with the participation of Claude Fortin and Peter Campbell (INRS). The research builds on Environment Canada funding for study of lanthanide elements and includes the participation of Avalon Rare Metal Inc., Perkin Elmer and Natural Resources Canada (CANMET labs).
- Chris Wood and Som Niyogi (University of Saskatchewan), with the able assistance of Kevin Brix, have received complementary funding from the NSERC CRD program for the same research project: "*Developing Experimental Data for a Multi-Metal BLM framework – Back to Basics*". These additional funding will allow examination of a greater range of metal combinations as well as intracellular speciation work at the Canadian Light Source

- Chris Wood and Sigal Balshine (McMaster University Psychology Dept.) have received an NSERC RTI award (equipment grant) to purchase a “*Fish Behavioural Choice System*” from Loligo (Denmark). The system will allow assessment of how toxicant exposure may affect a fish’s ability to choose an appropriate salinity, pH, dissolved O₂ level etc.
- Chris Wood and Kevin Brix received funding from CCME for a six month project entitled: “*Development of water quality guidelines for Pb and Fe*”. The project will review all available toxicity data on Pb and Fe and develop revised WQG for CCME that include the effects of various water quality parameters (hardness, pH, DOC) on metal bioavailability.

Upcoming meetings:



Conference presentations:

The following papers are going to be presented by the Metals Bioavailability Group in the 34th Annual SETAC North America Meeting, Nashville, Tennessee. Sunday the 17th to Thursday the 21st of November, 2013. In chronological order:

- Giacomini, M., Gillis, P.L., Bianchini, A., and Wood, C.M. Interactive effects of copper and dissolved organic matter on juvenile freshwater mussel physiology. Platform. *Use of Freshwater Mollusk Toxicity Data for Improved Conservation of Water and Sediment Quality. Monday 2:45pm, Jackson AB.*
- Smith, D. S., Vukov, O., Nasir, R., Cunningham, J., Chowdury, J. and McGeer, J. C. Life-cycle toxicity of lead to *Americamysis bahia* in a flow-through exposure including detailed investigation of lead analysis in water. Platform. *Fate and Effects of Metals: Marine Concerns. Tuesday 2:45pm, Washington B.*
- Cooper, C., Nasir, R., McGeer, J. C. and Smith, D. S. Influence of salinity and DOC on chronic Ni toxicity to the mysid *Mysidopsis bahia*. Platform. *Fate and Effects of Metals: Marine Concerns. Tuesday 3:10pm, Washington B.*
- Smith, D. S., Tait, T. Cooper, C., Cimprich, G., Chen, W., Guéguen, C. and McGeer, J. C. Free ion (Cu²⁺, Pb²⁺, Zn²⁺, Ni²⁺) measurements for predicting metal bioavailability to saltwater invertebrates at various DOC and salinity conditions. Poster TP180. *Fate and Effects of Metals. Tuesday, Exhibit Hall.*
- Nasir, R. and McGeer, J. C. Mitigating effects of dissolved organic matter on Cu toxicity to *Americamysis bahia* in estuarine waters. Poster TP185. *Fate and Effects of Metals. Tuesday, Exhibit Hall.*

- McGeer, J. C., Nasir, R., Cunningham, J. Duncan, J. and Smith, D. S. Salinity and dissolved organic mitigation of Cu toxicity in estuarine environments. Poster TP190. *Fate and Effects of Metals. Tuesday, Exhibit Hall.*
- Vukov, O., Verdin, A., Lu, C. and McGeer, J. C. Developing site specific understanding of the toxicity of cerium, dysprosium and samarium to *Hyalella azteca*. Platform. *Fate and Effects of Metals: Aquatic Biological Perspective: Toxicity Mechanisms. Wednesday 8:00am, Presidential A.*
- Zimmer, A.L, Brauner, C., and Wood, C.M. The effects of waterborne copper exposure on branchial and cutaneous ammonia excretion and sodium uptake in developing rainbow trout. Platform. *Fate and Effects of Metals: Aquatic Biological Perspective: Toxicity Mechanisms. Wednesday 9:15am, Presidential A.*
- Wood, C. M., Ng, T., Alsop, D. and Chowdhury, M. J. 2013. Interactions and relative contributions of chronic waterborne and dietary lead exposure to toxicity and accumulation in rainbow trout. Platform. *Fate and Effects of Metals: Aquatic Biological Perspective: Dietary and Bioconcentration. Wednesday 5:00pm, Presidential A.*
- Brix, K. V., Tellis, M. and Wood, C. M. 2013. The effects of metal mixtures on metal blinding to fish gills: Implications for development of a metal mixture Biotic Ligand Model. Platform. *Modeling and Interpreting Effects of Metals Mixtures. Thursday 4:25pm, Washington B.*
- Smith, D. S., Tait, T., Ashoka, M. and McGeer, J. C. Utility of fluorescence quenching to determine metal (Cu, Zn, Pb, Ni) speciation for saltwater solutions containing dissolved organic matter. Poster RP081. *Fate and Effects of Metals: Geochemical Perspective. Thursday, Exhibit Hall.*

The following peer reviewed papers and book chapters were published by the Metals Bioavailability Group (Nov. 2012 – Nov. 2013):

- Al-Reasi, H. A., Yusuf, U., Smith, D. S. and Wood, C. M. 2013. The effect of dissolved organic matter (DOM) on sodium transport and nitrogenous waste excretion of the freshwater cladoceran (*Daphnia magna*) at circumneutral and low pH. *Comp. Biochem. Physiol. C.* 158:207-215.
- Al-Reasi, H. A., Wood, C. M. and Smith, D. S. 2013. Characterization of freshwater natural dissolved organic matter (DOM): quality measures for direct and indirect interactions with organisms. *Environ. Int.* 59:201-207.
- Alsop, D. and Wood, C. M. 2013. Metal and pharmaceutical mixtures: is ion loss the mechanism underlying acute toxicity and widespread additive toxicity in zebrafish? *Aquat. Toxicol.* 140-141:257-267.
- Cardwell, R. D., DeForest, D. K., Brix, K. V. and Adams, W. J. 2013. Do Cd, Cu, Ni, Pb and Zn biomagnify in aquatic ecosystems? *Rev. Environ. Contam. Toxicol.* 226:101-122.

- Chen, W., Guguen, C. and Smith, D. S. 2013. Influence of water chemistry and dissolved organic matter molecular size on copper and mercury binding determined by multi-response fluorescence quenching. *Chemosphere*. 92:351-359.
- Cooper, C. A., Tait, T., Gray, H., Webster, G., Santore, R. C., McGeer, J. C. and Smith, D. S. 2012. Influence of salinity and dissolved organic carbon on acute Cu toxicity to the rotifer *Brachionus plicatilis*. *Environ. Sci. Technol.* Submitted.
- Esbaugh, A. J., Mager, E. M., Brix, K. V., Santore, R. and Grosell. M. 2013. Implications of pH manipulation methods for metal toxicity: not all acidic environments are created equal. *Aquat. Toxicol.* 130-131:27-30.
- Eyckmans, M., Lardon, I., Wood, C. M. and De Boeck, G. 2013. Physiological effects of waterborne lead exposure in spiny dogfish (*Squalus acanthias*). *Aquat. Toxicol.* 126:73-381.
- Giacomini, M., Gillis, P. L., Bianchini, A. and Wood, C. M. 2013. Interactive effects of copper and dissolved organic matter on sodium uptake, copper bioaccumulation, and oxidative stress in juvenile freshwater mussels (*Lampsilis siliquoidea*). *Aquat. Toxicol.* In Press.
- Jorge, M. B., Loro, V. L., Bianchini, A., Wood, C. M. and Gillis, P. 2013. Mortality, bioaccumulation and physiological responses in juvenile freshwater mussels (*Lampsilis siliquoidea*) chronically exposed to copper. *Aquat. Toxicol.* 126:137-147.
- Khan, F. R. and McGeer, J. C. 2013. Zn-stimulated mucus secretion in the rainbow trout (*Oncorhynchus mykiss*) intestine inhibits Cd accumulation and Cd-induced lipid peroxidation. *Aquat. Toxicol.* In press.
- Klinck, J. S. and Wood, C. M. 2013. In situ analysis of cadmium uptake in four sections of the gastro-intestinal tract of rainbow trout (*Oncorhynchus mykiss*) *Ecotoxicol. Environ. Safety.* 88:95-102.
- Klinck, J. S. and Wood, C. M. 2013. Gastro-intestinal transport of calcium and cadmium in fresh water and seawater acclimated trout (*Oncorhynchus mykiss*) *Comp. Biochem. Physiol. C.* 157:236-250.
- Leonard, E. M. and Wood, C. M. 2013. Acute toxicity, critical body residues, Michaelis-Menten analysis of bioaccumulation, and ionoregulatory disturbance in response to waterborne nickel in four invertebrate species. *Comp. Biochem. Physiol. C.* 158:10-21.
- McClelland, G. B. and Scott, G. R. 2013. Muscle Plasticity. In: Evans, DH, Claiborne, J.B., and Currie, S (eds.). *The Physiology of Fishes*, 4th ed. CRC press, Baton Raton, FL.
- Munley, K. M., Brix, K. V. Panlilio, J. and Grosell. M. 2013. Growth inhibition in early life-stage tests predicts full life-cycle toxicity effects of lead in the freshwater pulmonate snail, *Lymnaea stagnalis*. *Aquat. Toxicol.* 128-129:60-66.
- Nadella, S. R., Tellis, M., Diamond, R., Smith, S., Bianchini, A. and Wood, C. M. 2013. Toxicity of lead and zinc to developing mussel and sea urchin embryos: Critical tissue residues and effects of dissolved organic matter and salinity. *Comp. Biochem. Physiol. C.* 158:72-83.

- Nogueira, L. S., Wood, C. M., Gillis, P. L. and Bianchini, A. 2013. Isolation and fractionation of gill cells from freshwater (*Lasmigona costata*) and seawater (*Mesodesma mactroides*) bivalves for use in toxicological studies with copper *Cytotechnology*. In Press.
- Ransberry, V. E., Blewett, T., and McClelland, G. B. 2013. The oxidative stress response in freshwater-adapted killifish, *Fundulus heteroclitus* to acute copper and hypoxia exposure. *Comp. Biochem. Physiol. C*. Accepted, in revision.
- Sandhu, N., McGeer, J. C. and Vijayan. M. 2013. Exposure to environmental levels of waterborne cadmium impacts corticosteroidogenic and metabolic capacities, and compromises secondary stressor performance in rainbow trout. *Aquat. Toxicol.* Manuscript accepted.
- Tellis, M. S., Lauer, M. M., Nadella, S., Bianchini, A. and Wood, C. M. 2013. Ionic status, calcium uptake, and Ca²⁺-ATPase activity during early development in the purple sea urchin (*Strongylocentrotus purpuratus*). *Comp. Biochem. Physiol. A*. 166:272-277.
- Tellis, M. S., Lauer, M. M., Nadella, S., Bianchini, A. and Wood, C. M. 2013. Sublethal mechanisms of Pb and Zn toxicity to the purple sea urchin (*Strongylocentrotus purpuratus*) during early development. *Aquat. Toxicol.* In revision.

The following platforms and posters were presented by the Metals Bioavailability Group (Nov. 2012 – Nov. 2013):

- Ashoka, M., McGeer, J. C. and Smith, D. S. 2013. Evaluation of fluorescence quenching as a speciation method for lanthanides (La³⁺, Eu³⁺) and metal cations (Cu²⁺, Ni²⁺, Zn²⁺, Pb²⁺) in model and natural systems. Workshop on the ERA of data poor metals and metal mixtures, Sept., Gatineau, Quebec.
- Blewett, T. A., Nyogi, S., Fehsenfeld, S. and Wood, C. M. 2013. Making sense of nickel toxicity in saline waters: nickel accumulation in the estuarine crab, *Carcinus maenas*. Canadian Society of Zoologists Annual Meeting, May, Guelph, Ontario.
- Chen, W., Gueguen, C., Smith, D. S., Galceren, J., Puy, J. and Ecompany, E. 2013. Study of Zn speciation in presence of dissolved organic matter (DOM) using combination of Absence of Gradient and Nernstian Equilibrium (AGNES), potentiometry, and fluorometry with application of Non-ideal Competitive Adsorption Model (NICA) and Conditional Affinity Spectrum (CAS). Environmental Analysis Conference, Sept., Toronto, Ontario.
- Chan, K., Smith, D. S. and McGeer, J. C.* 2013. The role of Ca, Mg and dissolved organic matter as toxicity modifying factors in boreal shield lakes. 40th Annual Aquatic Toxicity Workshop, Oct., Moncton, New Brunswick.
- Costa, E-J. and McGeer, J. C. 2013. The acute and chronic toxicity of three forms of nanoparticle silver and silver nitrate to *Daphnia pulex*: is uptake and toxicity related to particle dissolution? 40th Annual Aquatic Toxicity Workshop, Oct., Moncton, New Brunswick. *Oral presentation, awarded the Dr. Rick Playle Award for Outstanding MSc Thesis in Aquatic Toxicology*
- Dwyer, R., Gace, L., Earley, P., Swope, B., Smith, D. S. and Gray, H. E. 2013. Due diligence investigations of novel copper alloy mesh materials in aquaculture measured copper release rates, modeled and measured ambient concentrations, measured uptake in cultured fish, and predicted bioavailability to other aquatic organisms. European Aquaculture Society, August, Trondheim, Norway.

- Gray, H. E., Gace, L., Dwyer, R. L., Santore, R. C., McGeer, J. C. and Smith, D. S. 2013. Field testing of copper alloy cages in British Columbia: comparison of measured copper to ambient water quality criteria. Aquaculture Canada Conference, June, Guelph, Ontario.
- Jabari, N. and McClelland, G. B. 2013. The combined physiological effects of Cu and hypoxia in the common killifish, *Fundulus heteroclitus*, measured through oxygen-dependent gene and protein expression. Comparative Physiology and Biochemistry Workshop, Feb., Rice Lake, Ontario.
- Leonard, E. M., Marentette, J., Balshine, S. and Wood, C.M. 2013. How does Ni bioaccumulation relate to Ni toxicity and behavioural effects in *Oncorhynchus mykiss* and *Neogobius melanostomus* following an acute Ni exposure? Canadian Society of Zoologists Annual Meeting, May, Guelph, Ontario.
- Leonard, E. M., Marentette, J., Balshine, S. and Wood, C. M. 2013. Behaviour and nickel bioaccumulation: Is there a link? Laurentian SETAC 18th Annual Meeting, June, Hamilton, Ontario.
- Livingstone, K., Smith, D. S. and McGeer, J. C. 2013. Influence of dissolved organic matter source in mitigating the acute and chronic toxicity of Cu to *Hyalella azteca*: Does ecosystem disturbance influence quality? 18th Annual Laurentian SETAC Conference. June, Hamilton, Ontario.
- Livingstone, K., Smith, D. S. and McGeer, J. C. 2013. Does ecosystem disturbance alter the capacity of dissolved organic matter to mitigate the toxicity of Cu to *Hyalella azteca*? 40th Annual Aquatic Toxicity Workshop, Oct., Moncton, New Brunswick.
- Livingstone, K., Lester, F., Smith, D. S. and McGeer, J. C. 2013. Case study 1, Linking ecosystem characteristics and DOM quality. Environment Canada Staff Training Workshop I: Role of dissolved organic matter on environmental behaviour of metals. June, Gatineau, Quebec.
- Livingstone, K. and J. McGeer. 2013. Influence of ecosystem disturbance on dissolved organic matter source quality in mitigating the acute and chronic toxicity of Cu to *Hyalella azteca*. Canadian Society of Zoologists Annual Conference. May 13-17, 2013. Guelph. ON. (oral presentation).
- McGeer, J. C. 2013. Water science initiatives at Laurier. University of Chongqing, August, Chongqing PRC.
- McGeer, J. C. 2013. Introduction to dissolved organic matter. Environment Canada Staff Training Workshop I: Role of dissolved organic matter on environmental behaviour of metals. June, Gatineau, Quebec.
- McGeer, J. C., Clifford, M., Kozlova, T., Hicks, K., Chan, K. and Smith, D. S. 2013. Toxicity mitigation and prediction modelling. Environment Canada Staff Training Workshop I: Role of dissolved organic matter on environmental behaviour of metals. June, Gatineau, Quebec.
- McGeer, J. C., Cooper, C. A., Nasir, R., Cunningham, J., Depalma, S., Smith D. S. and W.R. Arnold, R. W. 2013. Toxicity mitigation by dissolved organic matter in marine water. Environment Canada Staff Training Workshop I: Role of dissolved organic matter on environmental behaviour of metals. June, Gatineau, Quebec.
- McGeer, J. C., Khan, F., Keller, W., Gunn, J., Welsh, P., Yan N. and Wood, C. M. 2013. Case study 3. Modelling approaches for integration of DOM and multi-metal interactions to estimate recovery of Sudbury Lakes. Environment Canada Staff Training Workshop I: Role of dissolved organic matter on environmental behaviour of metals. June, Gatineau, Quebec.

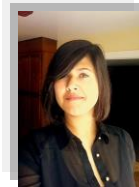
- McGeer, J. C., Smith, D. S., Fortin, C., Campbell, and Wilkinson, K. 2013. Bioavailability, toxicity, mobility and modeling of data poor metals. NRC and Rare Earth Elements R&D Workshop, June, Ottawa, Ontario.
- Nasir, R. and McGeer, J. C. 2013. Interactive effects of salinity and dissolved organic matter on Cu toxicity and bioaccumulation in *Americamysis bahia*. Canadian Society of Zoologists Annual Meeting, May, Guelph, Ontario.
- Ng, T.Y-T., Chowdhury, M. J. and Wood, C. M. 2013. Effects of water quality parameters on Cu toxicity to rainbow trout and development of a chronic Biotic Ligand Model. Laurentian SETAC 18th Annual Meeting, June, Hamilton, Ontario
- Ransberry, V. E., Blewett, T. A. and McClelland, G. B. 2013. Oxidative stress and metabolic responses in freshwater- and seawater-adapted killifish, *Fundulus heteroclitus*, exposed to copper. Comparative Physiology and Biochemistry Workshop, February, Rice Lake, Ontario.
- Smith, D. S., Ashoka, M., El-Akl, P., Vukov, O., Gray, H., McGeer, J. C. and Wilkinson, K. J. 2013. Speciation of lanthanides & North–South NOM comparisons. Workshop on the ERA of data poor metals and metal mixtures, Sept., Gatineau, Quebec.
- Tellis, M., Brix, K. V. and Wood, C. M. 2013. Developing experimental data for a multi-metal BLM framework. Canadian Society of Zoologists Annual Meeting, May, Guelph, Ontario.
- Tellis, M. S., Brix, K. V. and Wood, C. M. 2013. Investigating multi-metal interactions at the gill of the rainbow trout: The next step in the development of the Biotic Ligand Model. Laurentian SETAC 18th Annual Meeting, June, Hamilton, Ontario
- Tellis, M., Brix, K. V. and Wood, C. M. 2013. Characterizing acute metal interactions at the gills of rainbow trout: towards the development of a multi-metal BLM. Workshop on the ERA of data poor metals and metal mixtures, Sept., Gatineau, Quebec.
- Verdin, A., Smith, D. S. and McGeer, J. C. 2013. The effects of cationic competition on acute Sm toxicity to the freshwater invertebrate *Hyalella azteca*. Workshop on the ERA of data poor metals and metal mixtures, Sept., Gatineau, Quebec.
- Verdin, A., Vukov, O. Lu, C. Smith, D. S. and McGeer, J. C.* 2013. Factors influencing rare earth element impacts in aquatic invertebrates. Workshop on the ERA of data poor metals and metal mixtures, Sept., Gatineau, Quebec.
- Vukov, O. and McGeer, J. C. 2013. Cerium toxicity to *Hyalella azteca* and *Daphnia pulex*: protective effects of cationic competition and dissolved organic matter. Canadian Society of Zoologists Annual Meeting, May, Guelph, Ontario.
- Vukov, O., Lu, C., Smith, D. S., Dixon, G. and McGeer, J. C. 2013. The effects of Na, Mg and Ca on acute Dy toxicity towards freshwater invertebrates *Daphnia pulex* and *Hyalella azteca*. Workshop on the ERA of data poor metals and metal mixtures, Sept., Gatineau, Quebec.
- Wilkie, M. P., Baltzer, J., Quinton, W., Gordon, J., McGeer, J. C., Lister, A. and MacLatchy, D. 2013. Effects of permafrost thaw and land use change on toxicants and fish health in the Dehcho. 2nd Annual A Return to Country Foods Workshop, August, Kakisa. NWT.

Research Highlight:

Effects of Salinity and DOM Source on Cu Toxicity to *Americamysis bahia*

Rabia Nasir

Department of Biology, Wilfrid Laurier University



Introduction

The aim of this research was to test the interaction of salinity and DOM source on Cu toxicity to *Americamysis bahia*. Both acute lethality (96 h) as well as 7 d growth tests were used across a range of salinities. The overall goal is to contribute to the development of impact prediction models for Cu in estuarine systems.

Materials and Methods

Americamysis bahia were purchased from Aquatic Research Organism (ARO) and testing and culture was done in reconstituted water (Kent Marine Mix) adjusted to the appropriate salinity.

Effect of Salinity

Both acute lethality (96h) and 7-day growth and survival tests were conducted to test the effects of salinity on Cu toxicity. Acute toxicity was tested at 5, 10, 15, 20, 25, 30 & 40 ppt. Cu atomic absorption standard was used to make test solutions (ranging from 50 – 800 µg Cu/L, mortality was the endpoint and water samples were collected before test initiation and after 96 h. Total and dissolved Cu concentrations and DOC concentrations were also measured.

The 7-day survival and growth tests were conducted with 7 d old mysids at salinities of either 15 or 25 ppt. Survival, dry weight and brood sac development index (score ranging from 1 (immature) to 5 (sexually mature)) were the measured endpoints. Water samples were collected for measurement of Cu and DOC concentrations.

Effects of Acclimation Salinity

To test whether transfer to different salinity contributed to the response to Cu in acute tests mysids were cultured at 15 and 25 ppt. Neonates were collected from each culture group were tested (96 h lethality) at salinities of 5, 15 and 25 ppt by directly transferring neonates into

required salinity. Tested Cu exposure concentrations ranged from 50- 800 µg/L.

Effects of DOC

96 h acute and 7-day chronic toxicity tests were done to determine if the protective effects of DOM on Cu toxicity varied with source. Four different sources were tested at a salinity of 25 ppt and DOC concentration of 4 mg C/L. Water samples were collected daily for both Cu and DOC analysis.

Results and Discussion

Effect of Salinity on Cu toxicity

The acute toxicity of Cu was reduced with increasing salinity up to 30 ppt (Fig 1). At salinities of 35 and 40 ppt toxicity was increased. These results are similar to the studies of Grosell et al. (2007) and Pinho et al. (2010) where test organisms exhibited sensitivity to Cu at both high as well as low salinities. This increased sensitivity of the organism to Cu at the salinity extremes was likely due to an inability to maintain osmoregulatory homeostasis.

When mysids were acclimated to either 15 or 25 ppt and then tested a 5, 15 or 25 ppt there were no difference between the acclimation groups (Fig 2). *A. bahia* are osmoregulators and are able to adjust to salinity changes quickly, within 95 min of transfer according to (De Lisle et al., 1987). This explains the lack of difference between 15 and 25 ppt acclimated and also demonstrates that they are good model organisms for testing the impacts of contaminants in estuarine environments.

Salinity also provided protective effects in the 7-day tests for the survival endpoint but not for growth. Fewer mortalities were observed at salinity of 25 ppt in comparison to that of 15 ppt (Fig. 3). The LC₅₀ was increased 2 fold. Whole body dry weight was used as measure of growth and expressed as a percent of controls.

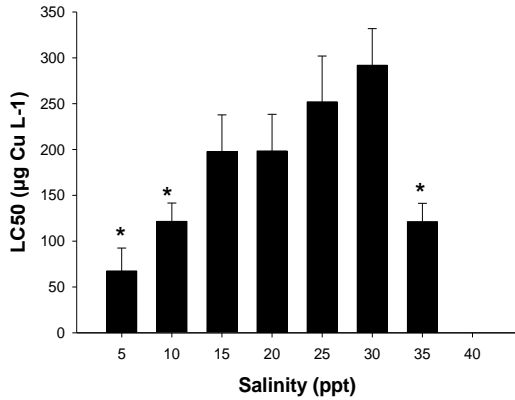


Figure 1. 96 h LC₅₀ values for *A. bahia* exposed to Cu at different salinities. Significant differences from the LC₅₀ at 25 ppt are shown with *s.

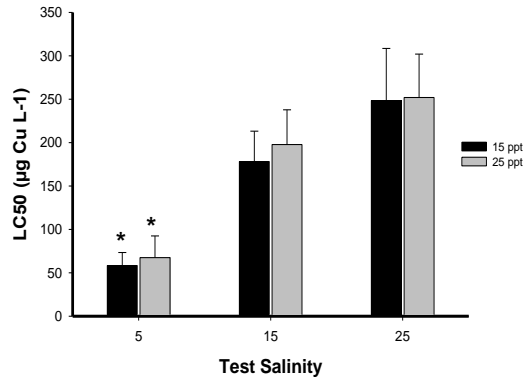


Figure 2. Comparison of acute Cu toxicity in mysids acclimated to either 15 or 26 ppt and subsequently tested at 5, 15 and 25 ppt. Significant differences from the LC₅₀ at 25 ppt are shown with *s.

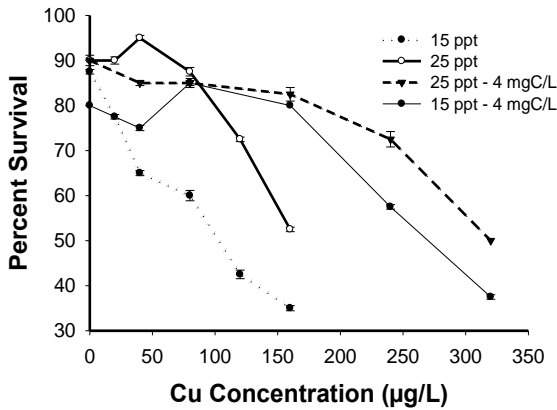


Figure 3: Survival (%) during 7 d tests at 15 and 25 ppt as well as with an addition of 4 mg DOC/L at 25 ppt.

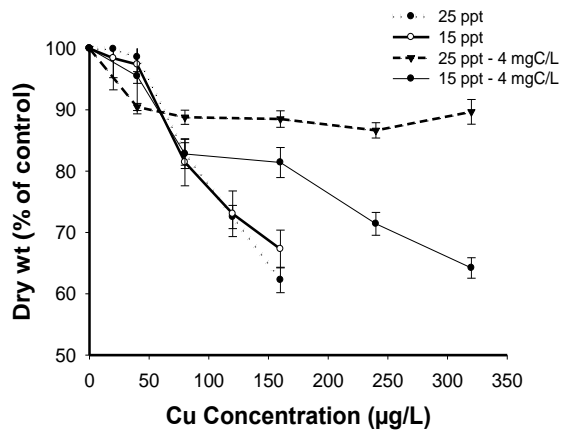


Figure 4: Growth of *A. bahia* as a percent of control for 7-day tests with Cu. No significant effect of salinity is observed on mysids but DOC provided protection against the effects of Cu.

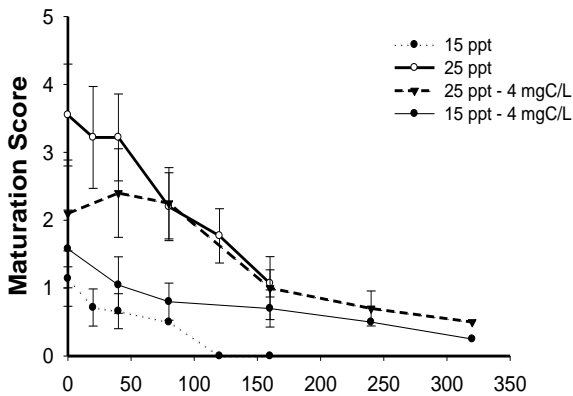


Figure 5: Brood sac score for mysid exposed to Cu at either 15 or 25 ppt salinity and the latter with 4 mg DOC added.

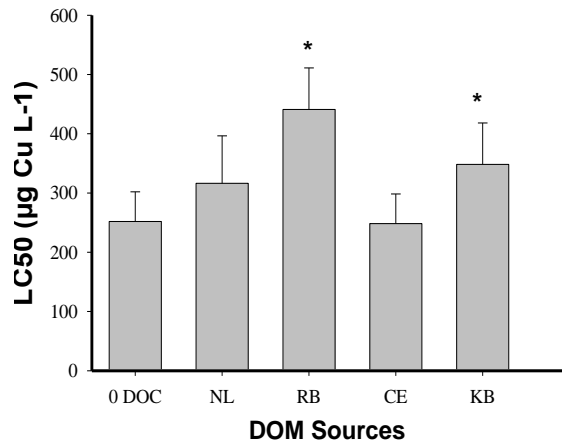


Figure 6: Acute toxicity of Cu with DOM sources added at 4 mg DOC/L. LC₅₀s significantly difference from the test with no added DOC are shown with a *.

The effect of Cu on whole body weight was similar at both salinities (Fig. 4) although there were fewer surviving mysids at 15 ppt in comparison to 25 ppt, the ones that did survive grew just as well. Finally broodsac size was also measured (note that the majority of the mysids do not reach sexual maturity by day 14. Sexual maturation in females was characterized by using a scoring system from 1 to 5. In unexposed controls there was an effect of salinity on broodsac development which was independent of Cu (Fig. 5). Therefore it was not possible to study the effects of salinity on Cu toxicity using this endpoint.

Effects of DOM on Cu toxicity

Test with DOM were conducted at a salinity of 25 ppt. DOM sources were collected by reverse osmosis concentration near coastal areas with minimal anthropogenic inputs from fresh water upstream. There was not a big difference in protective effects (Fig 6). Two sources offered no protection and two others did. The highest level of protection was provided by the Rankin Brook source, nearly a 2 fold compared to the LC50 with no added DOC (Fig. 6).

A similar protective effect was observed in 7-d tests. LC50 values increased by two fold at 25 ppt with 4 mg C/L of Kouchibouguac DOM

(Fig. 3 & 4). Growth was also improved with the addition of DOM (Fig. 4) however no differences were observed in sexual maturity score (Fig. 5). The sexual maturity score was a sensitive measure at 25 ppt salinity but development was inhibited by lower salinity and therefore it was not considered as a good endpoint for comparing effects at different salinities.

Conclusions

The acute toxicity of Cu was greater at low and high salinities. Testing at 15 and 25 ppt showed no significant difference in 96h LC50 but significant differences in 7-d survival tests. DOM at 4 mg DOC/L provided relatively little protection in acute toxicity and greater mitigation in 7-d tests.

To develop an improved understanding of how Cu toxicity varies in estuarine environments future experiment will examine relationships between toxicity and bioaccumulation.

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An amoeba with a rifle: .-

And one with large eyebrows: "."