2013

10th International Phytotechnologies Conference Proceedings

International Phytotechnology Society

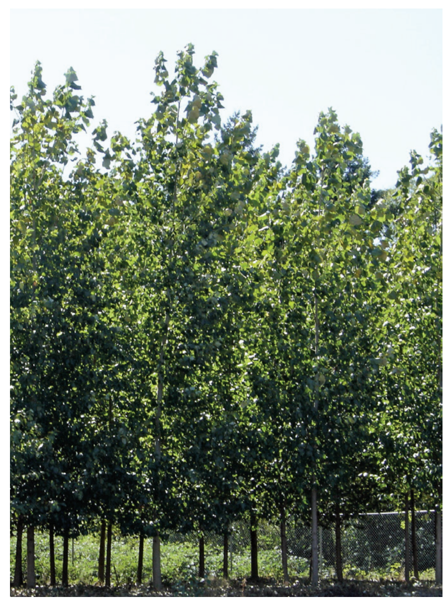
PHYTOTECHNOLOGIES

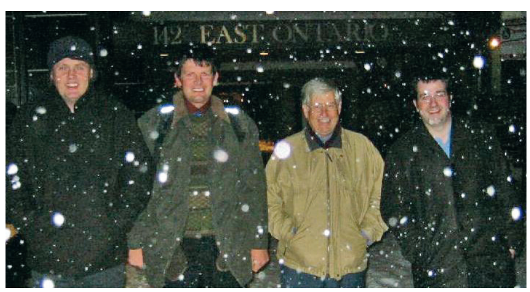
10th International Conference









October 1-4, 2013

Syracuse, New York, USA

Hosted by the International Phytotechnology Society and the
State University of New York College of Environmental Science and Forestry

The International Phytotechnology Society and the State University of New York College of Environmental Science and Forestry are both proud and happy to welcome you to Syracuse to the 10th International Phytotechnologies Conference.

In May 2000, the first ever conference focused entirely on phytoremediation in the United States was hosted by the US Environmental Protection Agency in Boston, MA. This was followed in March 2003 with the 'snowstorm' conference in Chicago and much warmer conference in April 2005 in Atlanta. At the Atlanta conference, we started the tradition of including conference tours with our inaugural tour being hosted by the US Department of Energy at the Savannah River Site in South Carolina.

In 2006, the International Phytotechnology Society was formed, and it assumed the lead role in hosting the conferences, starting with Denver in 2007. This started the tradition of a rotational conference schedule to bring the conference to international venues on a biannual basis – one year in North America, and alternating years on other continents. This started with Nanjing, China in 2008; St. Louis, MO in 2009; Parma, Italy in 2010; Portland, OR in 2011; and Hasselt, Belgium in 2012 and now in Syracuse, NY in 2013 for our 10th conference.

Each conference expanded on the one before it just a little bit. Nanjing was our first conference at an international venue, St. Louis was the first to have the National Institute of Environmental Science sponsored Phyto Scholars program, Parma had the first truly formal Conference Dinner (with an opera, no less!).

We have now reached an important milestone, our 10th conference. We here in New York are proud to host this conference. We have received over 360 abstract submissions, with 49 countries represented. We hope to make this 10th International Phytotechnologies Conference special for all our attendees. We have excellent speakers lined up, covering not only the 'traditional' phytoremediation topics, but also sessions on carbon sequestration, carbon amendments to the soil, biofuels, wetlands, long term monitoring of sites, and intertwining of human health and plants.

After hours, we will be hosting the conference dinner at the Milton J. Rubenstein Museum of Science and Technology, which has been reserved for our private use. The second night, we will supply transportation for conference goers to visit Destiny USA, the 6th largest shopping mall in America (hey, when the snow falls, we need something to occupy our time here in Syracuse!).

We hope that you will find the meeting beneficial; learning about new results and methods of plant-based technologies, networking with new people and meeting up with old friends.

We also hope that you take the time to enjoy central New York, and take home some NY State maple syrup, some Finger Lakes wine, or memories of visiting the Adirondacks State Park, the largest protected wilderness area in the continental US.

We welcome you here to learn, explore and enjoy the 10th International Phytotechnologies Conference!

The Organizing Committee

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Acknowledgements

Organizing Committee

Committee Chair, **Dr. Lee Newman**, *SUNY College of Environmental Science and Forestry*

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Congratulations to the 2013 IPS Phytoscholars:

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Hayden Ausland
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Samuel Pierce
Bryan Quah Kah Ming
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Shawn Shifflet
Stephen Via
Dennis Wang
Yuangen Yang
Muhammad Yasin
Weilan Zhang

The 2013 IPS Phytoscholar Awards are sponsored by the NIEHS Superfund Research Program. Please stop by the SRP Information Table to learn about research and new funding opportunities, including the recent call "Biogeochemical Interactions."

Three Poplar Trees in the Autumn, Claude Monet (1891)


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10th International Phytotechnologies Conference

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The 10th International Phytotechnologies Conference is co-hosted by the International Phytotechnology Society (IPS), State University of New York College of Environmental Science and Forestry (SUNY-ESF), and the Department of Environmental Forest Biology at SUNY-ESF.

Thank you to our 2013 Conference Sponsors!

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Special thanks to BP/David Tsao and Walt Eifert for supporting the Student Presentation Awards at the 10th International Phytotechnologies Conference.

10th International Phytotechnologies Conference Agenda

Tuesday, 1 October 2013		
8:00	**Workshop Registration** *at Convention Center Bar*	
9:00	**Workshop Departure/Return Times –** *Workshop vehicles will depart from Convention Center Entrance*	
	10:00 – 16:30	**Workshop 1:** Green Roof Workshop
	10:00 – 16:30	**Workshop 2:** Onondaga Lake Visit
	8:30 – 16:30	**Workshop 3:** Practicing Phytotechnologies
	14:00 – 16:30	**Workshop 4:** Walking Tour of SUNY-ESF
	9:30 – 16:30	**Workshop 5:** Finger Lakes Winery Tour
10:00 – 15:00	**Conference Registration** *at Convention Center Bar*	
16:00	**Conference Registration** *at the SUNY College of Environmental Science and Forestry Gateway Center*	
17:00 – 20:00 *17:15*	**Reception** *at the SUNY College of Environmental Science and Forestry Gateway Center* *Buses will depart from the Convention Center Entrance at 16:45* **Welcome** Dr. Cornelius B. Murphy Jr., *President, SUNY College of Environmental Science and Forestry*	

Wednesday, 2 October 2013	
7:00	**Check-in and Continental Breakfast** *at Convention Center Bar and in Convention Center A & B*
8:30	**Welcome and Introduction** *in Cotillion Room* Dr. Lee Newman, *Associate Professor, SUNY College of Environmental Science and Forestry* Dr. Jason White, *Chief Scientist, Connecticut Agricultural Experiment Station and President of IPS* Katherina Searing, *Associate Director for Professional Education and Non-credit Programs, SUNY College of Environmental Science and Forestry* Dr. Barbara Zeeb, *Professor, Royal Military College of Canada*
9:00	**Plenary Session** *in Cotillion Room* **How it All Began: My Own Journey and Some Visions of the Future of Phytotechnologies for Inorganics** Dr. Alan J.M. Baker, *Professor, School of Botany, The University of Melbourne* **Gordon Award Recipient Speech** Dr. Nelson Marmiroli, *Professor, University of Parma*
10:40	**Break, Poster Viewing (*1A-103A*), and Sponsor & Exhibitor Interactions** *in Convention Center A & B* Quick Talk Presentations: **1.** Melati Ferianita Fachrul, **2.** Zehra Sapci
11:10	**Mini Plenary Session** *in Cotillion Room* **Session 1:** Guangshu Zhai **Session 2:** Andre Gerth **Session 3:** Timothy Volk **Session 4:** Mary Beth Leigh **Session 5:** Elisha Tel-Or and Yongming Luo **Session 6:** Liz Rylott
12:10	**Lunch** *in Cotillion Room* **and Poster Viewing (*1A-103A*)** *in Convention Center A & B*

Wednesday, 2 October 2013 *(continued)*			
13:45	**Concurrent Sessions**		
	1: Persistent Organic Pollutants *Ballroom West*	**2: Constructed Wetlands** *Ballroom Center*	**3: Production of Biofuels and Plant Biomass** *Ballroom East*
	Session Chairs: *Barbara Zeeb & Guangshu Zhai*	**Session Chairs:** *David Tsao & James Jordahl*	**Session Chairs:** *Eugenia Olguin & Timothy Volk*
13:45	Taking Advantage of Native Colonizers to Phytoextract of Persistent Organic Pollutants (POPs) at Contaminated Field Sites in Canada – **Zeeb**	Experimental Study of Flow patterns through aquatic vegetation – **Anim**	Utilization of energy plants for phytoremediation purposes – its working? – **Vanek**
14:05	Plant-mediated Dissipation of Lindane from Soil – **Abhilash**	Dewatering and Treatment of Fishfarm Sludge in Vertical Flow Treatment Wetlands Planted With Macrophytes – **Biang**	A Biorefinery for the Production of Biogas from Aquatic Plants and Biodiesel from Microalgae and Wastewater – **Olguin**
14:25	Phyto Treatment of Polychlorinated Biphenyls Demonstrated in Laboratory and Field – **Liang**	Field Assessment of A Constructed Wetland Used for Slag Leachate Remediation – **Hunter**	Altered nitrogen source impacts plant biomass and cell wall formation – **Coleman**
14:45	Accumulation and Fractionation of PCBs in Different Parts of Alfalfa (Medicago sativa L.) – **Teng**	Performance and Mechanisms of Contaminant Removal from Wood Leachate in a Treatment Wetland – **Tao**	Developing Camelina sativa as a dedicated biofuel crop: enhanced oil yield and quality via manipulating triacylglycerols synthesis pathway – **Parkash**
15:05	Transgenic Plants in Rhizo/Phytoremediation of Polychlorinated Biphenyls and Evaluation of their Endophytic Microflora – **Novakova**	Aerobic Cometabolism of a Suite of Chlorinated Hydrocarbons in Flow-Through Wetland-Plant Mesocosms – **Struckoff**	The Effects of Planting Density and Fertilization rate on Phytoextraction of Trace Elements Using Sunflower as Bio-fuel Plants – **Kim**
15:25	Method to assess phytoremediation potential of plants – **Reddy**	Remediation of Shallow Groundwater Impacted With Chlorinated Ethenes Utilizing an Engineered Wetland – **Sauer**	Salinity Gradients and Biomass Accumulation in a Planted Willow Ring – **Mirck**
15:45	**Break, Poster Viewing (*1A-103A*), and Sponsor & Exhibitor Interactions** *in Convention Center A & B* Quick Talk Presentations: **3.** Brigitta Tóth, **4.** Sheikh Saeed Ahmad		

Wednesday, 2 October 2013 *(continued)*

16:15	**Concurrent Sessions**		
	4: Plant Associated Microorganisms *Ballroom West*	**5: Aquatics and Metal Remediation** *Ballroom Center*	**6: Explosives** *Ballroom East*
	Session Chairs: *Jaco Vangronsveld & Michel Mench*	**Session Chairs:** *Yongming Luo & Elisha Tel-Or*	**Session Chairs:** *Liz Rylott & Om Parkash*
16:15	Plant-associated bacteria: an important key to a successful application of phytoremediation – **Vangronsveld**	Phytoremediation in China: Advances and Perspectives – **Luo**	Plant community response to explosive soil contamination and potential for airborne detection – **Via**
16:35	Effect of plant growth promoting bacteria, Pseudomanas putida UW4 on plant biomass yield and phytoremediation of mixed PAH-contaminated soil – **Afegbua**	Plant Based Technologies for the Removal of Toxic metals and Organic Pollutants **– Tel-Or**	Phytodetoxification of the environmental pollutant 2,4,6-trinitrotoluene (TNT) is mediated by glutathione transferases – **Rylott**
16:55	Shift in Naphthalene-Degrading Bacterial Communities Associated with Rhizoremediation of Diesel – **McFarlin**	Phytoremediation of Chromium-VI Contaminated Groundwater by a Rhizofiltration Pilot - **Kalogerakis**	Grasses and bacteria joining forces: bioaugmented rhizoremediation with common bent for clean-up of 2,4,6-trinitrotoluene – **Thijs**
17:15	Interaction of Cd/Zn hyperaccumulating plant (*Sedum alfredii*) and rhizosphere bacteria on metal uptake and removal of phenanthrene – **Li**	The Study on Cadmium Accumulation by Eichhornia crassipes under water pollution conditions – **Shuvaeva**	Proteomic profiling of Vetiver grass (Chrysopogon zizanoides) under 2,4,6 Trinitrotoluene (TNT) stress – **Das**
17:35	An *Arabidopsis* model for seed endophyte-assisted plant growth upon Cd exposure – **Truyens**	An *Engineered Phytoremediation*^{SM} System for Hydraulic Control of Brackish Groundwater – **Gestler**	Rapid Phytoforensics for Energetics – **Burken**
17:55		Root Growth Responses, Mercury in Cell Walls and Protoplasts and Mercury-binding Thiol Peptides of Water Hyacinth under Mercury Exposure – **Rivero**	
18:25	**Buses depart for Conference Dinner** *from Convention Center Entrance*		
18:50	**Conference Dinner** *at the Milton J. Rubenstein Museum of Science and Technology*		

Thursday, 3 October 2013			
8:00	**Check-in and Continental Breakfast** *at Convention Center Bar and in Convention Center A & B*		
8:30	**Plenary Session** *in Cotillion Room* **The Challenges We Face Now** Dr. David Tsao, *Americas Remediation Technology Manager, BP Remediation Management*		
9:30	**Mini Plenary Session** *in Cotillion Room* **Session 7**: Heather Henry **Session 8**: Douglas Daley **Session 9**: Kate Kennen		
10:00	**Break, Poster Viewing (*1B-102B*), and Sponsor & Exhibitor Interactions** *in Convention Center A & B* Quick Talk Presentations: **5.** Zhaoping Zhong, **6.** Muhammad Shafiq		
10:30	**Concurrent Sessions**		
	7: Health and Exposure Risk *Ballroom West*	**8: Covers and Stabilization** *Ballroom Center*	**9: Building Integrated Vegetation** *Ballroom East*
	Session Chairs: *Heather Henry & Stephen Ebbs*	**Session Chairs:** *Jaconette Mirck & Douglas Daley*	**Session Chairs:** *Clayton Rugh & Kate Kennen*
10:30	Use of plants as passive samplers for volatile organic compounds (VOCs) in indoor environments – **Doucette**	Scaling assisted phytostabilization from the greenhouse to the field at the Iron King Mine-Humboldt Smelter Superfund Site - **Gil-Loaiza**	The Oncenter green roof: a tool for managing urban stormwater - **Squier**
10:50	Bioaccessibility and bioactivity of selenium from Se-hyperaccumulated cereal crops: a step towards their use for developing natural Se supplements – **Nagaraja**	Phytotechnology Cover for Industrial Landfill Closure – **Abbene**	The Use of Native Plants on an Intensive Green Roof: Initial Results – **Toland**
11:10	Effect of agricultural residues as soil amendments on cadmium accumulation in rice plants – **Suksabye**	Assessing bacterial colonization of plant roots as a bio-indicator of phytostabilization sustainability using fluorescent in situ hybridization (FISH) - **Herbertson**	Green Roof Runoff Characterization: nutrient loading and erosion control on a newly planted green roof – **Harper**
11:30	Regulation of cadmium accumulation and bioaccessibility in wheat – **Sankaran**	Effects of varied N concentration on a variety of willow genotypes – **Farrar**	Impact of Planted Biofilters on Contaminant Loads and Ambient Humidity in Canadian Residences During the Summer 2013 – **Darlington**
11:50	Quantifying the Effects of Horticultural Therapy on Spinal Cord Injury Patients – **Collins**	Development of an Alternative Vegetative Cover Using Shrub Willows in Central, NY – **Volk**	Treatment of High Strength Organic Wastewater Using Green Walls – **Wolcott**
12:10	**Lunch** *in Cotillion Room* **and Poster Viewing (*1B-102B*)** *in Convention Center A & B*		

Thursday, 3 October 2013 *(continued)*			
13:40	**Mini Plenary Session** *in Cotillion Room* **Session 10:** Michel Mench **Session 11:** Anthony Eallonardo **Session 12:** Elizabeth Nichols **Session 13:** Michel Mench **Session 14:** Tomas Macek **Session 15:** Tomas Vanek		
14:45	**Concurrent Sessions**		
	10: Inorganics I *Ballroom West*	**11: Long Term Results and Restoration** *Ballroom Center*	**12: PAH/Petroleum Remediation** *Ballroom East*
	Session Chairs: *Elena Maestri & Nelson Marmirolli*	**Session Chairs:** *Sheldon Nelson & Donald Leopold*	**Session Chairs:** *Mary Beth Leigh & Walter Eifert*
14:45	Critical issues encountered in the promotion of arsenic phytoremediation from laboratory experiments to large scale application – **Lei**	Phytoremediation of petroleum and salt-impacted soils: Successfully meeting generic Tier 1 standards and making green technologies work – **MacNeill**	PAH Removal in Soils at a Phytoremediation Site in North Carolina – **McEachran**
15:05	Uranium uptake by hydroponically cultivated crop plants and its potential for environment decontamination – **Vanek**	Petroleum Phytoremediation in Cold Regions, a 16 Year Study – **Leigh**	Polycyclic aromatic hydrocarbons fate in urban area: Case Studies in Poland and Norway – **Gawronski**
15:25	Identification of the Genes Expressed in Willows during Phytoremediation – **Pitre**	Nitrate Remediation of Soil and Groundwater Using Phytoremediation – **Nelson**	Diesel Oil Degradation Triggered By Plant Growth Promoting Bacteria Isolated From Poplar Trees Growing On A Diesel Contaminated Plume – **Vangronsveld**
15:45	Role of HMA2 in accumulation of cadmium in two near isogenic lines of wheat – **Tavarez**	Valuation of Phytotechnology Benefits: More than Just 'Aesthetically Pleasing' – **Burken**	*Leucanthemum vulgare* flavonoid content during crude oil phytoremediation – **Noori**
16:05	Phytoremediation of lead (Pb) contaminated soils by Transgenic *Helianthus annuus L.* – **Vasavi**	Don't Call it Dirt! Increasing the Success of Phytoremediation and Ecological Restoration Projects through Soil Science – **Jordahl**	Phytoremediation to Degrade Total Petroleum Hydrocarbons (TPH) using Mixtures of Grass and Willow Species - **McIntosh**
16:25	Influence of arsenic and phosphorus competitive uptake on arsenic tolerance in bacteria and arsenic-hyperaccumulator Pteris vittata L - **Ghosh**	White Island: From Trash to Treasure - **Conklin**	
16:45	**Break, Poster Viewing (*1B-102B*), and Sponsor & Exhibitor Interactions** *in Convention Center A & B* Quick Talk Presentations: **7.** Abid Ali Ansari, **8.** O. Ayeni		

Thursday, 3 October 2013 *(continued)*			
17:15	**Concurrent Sessions**		
	13: Inorganics II *Ballroom West*	**14: Carbon Sequestration** *Ballroom Center*	**15: Fate and Remediation of Emerging Pollutants** *Ballroom East*
	Session Chairs: *Alan Baker & Nabeel Niazi*	**Session Chairs:** *Tomas Macek & William Headlee*	**Session Chairs:** *Joel Burken & Tomas Vanek*
17:15	Selenium phytoremdiation – bioremediation system: A long term sustainable approach to manage threatened agricultural areas – **Freeman**	Oxysterols Increase CO_2 Fixation by RuBisCO and the Activity of the Oxygen Evolving Complex – **Macek**	Nitrogen and COD removal from ink-production wastewater by *Cyperus alternifolius* and microbial communities – **Dolphen**
17:35	Repeated phytoextraction of four metal contaminated soils by *Sedum plumbizincicola*, a Cd/Zn hyperaccumulator – **Wu**	Modeling carbon sequestration and mitigation of greenhouse gases in phytoremediation systems – **Gopalakrishnan**	Translocation of Organic Compounds by Plants: Observations and Predictions – **Limmer**
17:55	*Miscanthus x giganteus* for phytoremediation of contaminated soils – **Pidlisnyuk**	Integrated approach to long-term carbon sequestration and landslide mitigation using Vetiver Grass Model – **Lavania**	Pharmaceuticals in the environment Model study of in vitro phytoextraction from aquatic media – **Smrcek**
18:15	A Long-term Study to Evaluate the Phytoremediation Potential of *Pteris vittata* L. and *Pityrogramma calomelanos* var. *austroamericana* – **Niazi**	Effects of Genotype and Environment on Carbon Sequestration of Hybrid Poplars in the North-Central USA - **Headlee**	Susceptibility of Riparian Wetland plants to Perfluorooctanoic acid (PFOA) Accumulation – **Mudumbi**
18:35	Estimation of the applicability of phytoremediation to As contaminated soil by tsunami sediments with native-grown fern in north-east region of Japan – **Sugawara**	Soil carbon sequestration: The need of hour – **Srivastava**	Long-Term Variation of Chlorinated Solvents in Trees – **Holmes**
19:10	**Student Outing & Dinner on Own** Transportation to Destiny USA provided. The bus will depart from the Convention Center Entrance. The bus will loop between Destiny USA and the Convention Center Entrance from 19:10 to 22:30. For return trips after 22:30, attendees will need to contact the Holiday Inn for the hotel shuttle.		
19:20	**ESF Biobus for the International Journal of Phytoremediation Dinner at Dinosaur BBQ will depart** *from Convention Center Entrance*		

Friday, 4 October 2013

8:00	**Continental Breakfast** *in Convention Center A & B*
8:30	**Plenary Session** *in Cotillion Room* **What Does the Future Hold** Dr. Lee Newman, *Associate Professor, SUNY College of Environmental Science and Forestry*
9:30	**Mini Plenary Session** *in Cotillion Room* **Session 16:** Jason White **Session 17:** Guido Fellet **Session 18:** Louis Licht & Dennis Hazel
10:00	**Break, Poster Viewing, and Sponsor & Exhibitor Interactions** *in Convention Center A & B* Quick Talk Presentation: **9.** Jirawan Torit
10:20	**Concurrent Sessions**

	16: Plant Nano Particle Interactions	17: Soil and Carbon Amendments	18: Storm and Wastewater
	Ballroom West	*Ballroom Center*	*Ballroom East*
	Session Chairs: *Marta Marmirolli & Jason White*	**Session Chairs:** *Ronald Zalesny & Gido Fellet*	**Session Chairs:** *Elizabeth Nichols & Louis Licht*
10:20	Accumulation of engineered nanoparticles in plant foods: Nutritional bioaccessibility and dietary exposure risks – **Ebbs**	Biochar application on hazardous materials: Variation in contaminants distribution and availability on polluted matrices – **Fellet**	Design and Testing of a Wastewater Irrigation System for Pilot-Scale Poplar Tree Nitrogen Processing Studies – **Ausland**
10:40	Toxicogenomics of CdS nanomaterials in Arabidopsis thaliana and Saccharomyces cerevisiae – **Marmirolli**	Interpreting Hybrid Poplar Responses to Soil and Foliar Applications of Bioenergy Byproducts via Vector Analysis – **Headlee**	Year-round Field-Scale Waste Water Treatment based on Phyto Processes – **Licht**
11:00	Wetlands and phytoremediation of nanoparticle metals – **Jacob**	Using Phyto-Recurrent Selection to Identify Favorable *Populus* Genotypes – **Zalesny**	The Bambou-Assainissement: a phytoremediation technology combining the wastewater treatment and the production of high added value biomass – **Piouceau & Panfili**
11:20	Changes in *Arabidopsis thaliana* gene expression in response to silver nanoparticles and silver ions – **Van Aken**	Uptake of heavy metals by three tropical native plants exposed to landfill leachate - **Peña-Salamanca**	Greening of a smelter for sustainable stormwater management – **Ludlow**
11:40	Multi-generational Impact of Cerium Oxide Nanoparticles on Plant Growth and Oxidative Stress of Brassica rapa – **Ma**	In situ Application of Activated Carbon and Biochar to Minimize PCB Bioavailability – **Denyes**	Phytoremediation of irrigation water with *Limnocharis flava, Thalia geniculata* and *Typha latifolia* in constructed wetlands – **Korsah**
12:00	Phytotechnology for Synthesis of Nanoparticles – **Sahi**	Impact of Bio-Char Addition to Soil on Weathered *p, p'*–DDE Accumulation in Zucchini Plants – **Isleyen**	

Friday, 4 October 2013 *(continued)*	
12:20	**Closing Session** *in Cotillion Room* **PhytoTech 2014!** Dr. Nicolas Kalogerakis, *Professor, Technical University of Crete* **Student Awards** Dr. Barbara Zeeb, *Professor, Royal Military College of Canada* Mr. Walter H. Eifert, *Vice President and Principal Hydrologist, ELM Site Solutions, Inc.* **Closing Comments** Dr. Lee Newman, *Associate Professor, SUNY College of Environmental Science and Forestry* Dr. Jason White, *Chief Scientist, Connecticut Agricultural Experiment Station and President of IPS*
13:00	**Conference Adjourns**
13:00	**Adirondack Ecological Center (AEC) Workshop** Vehicles depart at the close of the conference and return on Saturday 5 October at 17:00.

Plenary Speaker Biographies

Dr. Alan J.M. Baker, DSc, *Professor, School of Botany, The University of Melbourne*

How it All Began: My Own Journey and Some Visions of the Future of Phytotechnologies for Inorganics

BIOGRAPHY

Alan Baker gained a First Class Hons BSc in Botany (1970) and PhD in Plant Ecology (1974) from Imperial College, London. Subsequently he was appointed Independent Research Worker in the Unit of Comparative Plant Ecology (NERC), University of Sheffield, UK, then Lecturer in Botany 1976-1992, Senior Lecturer in Plant Ecology 1992-1995 and Reader (Associate Professor) in Environmental Science in the Department of Animal and Plant Sciences at the University of Sheffield (1995-2000). From October 2000 – August 2008, he was Professor of Botany (Ecology and Environmental Science) at the University of Melbourne, Australia where he headed the Applied Ecology Research Group in the School of Botany. The Group was involved in restoration and revegetation projects of mineral wastes, remediation of contaminated land and phytocapping of landfill sites, in addition to carrying out fundamental research on heavy metal uptake and accumulation and on the development of new phytotechnologies. On retirement from the University of Melbourne he was made an Honorary Professorial Fellow in the School of Botany and at the University of Sheffield, UK. He is also a Visiting Professor and Honorary Research Fellow in the Croucher Institute of Environmental Sciences at Hong Kong Baptist University, the School of Life Sciences at Sun Yat-sen University, Guangzhou, PR China and in the Centre for Mined Land Rehabilitation (CMLR) at the University of Queensland, Australia.

He was elected Fellow of the Linnean Society of London (FLS) in 1985, and Fellow of the UK Society of Biology (FSB, CBiol) in 1994 and is a Founder Member of the UK Chartered Institute of Ecology and Environmental Management; elected Fellow 2004 (FCIEEM). In 2006 Professor Baker was appointed to the Australian Department of Education, Science and Training Australia-India Research Fund Advisory Panel as an Expert Scientist in the field of bioremediation. In addition to extensive work experience in Europe, Australasia and the USA, he has worked in many developing countries including The Philippines, Thailand, New Caledonia, Sri Lanka, PR China, Democratic Republic of Congo, Brazil, Costa Rica, Cuba and Chile. Professor Baker has served on the Advisory Panel of the IUCN-ICMM Post-Mining Alliance. He is Director of Research for the Centre for Contaminant Geoscience (CCG) of the Australian consulting/contracting group, Environmental Earth Sciences International (EESI) Pty Ltd.

Professor Baker is the author/co-author of 186 original scientific papers and articles, 32 chapters in books and 230+ conference abstracts, and holds 3 international patents. He was Editor-in-Chief (Inorganic Contaminants) of the *International Journal of Phytoremediation* 1999-2009 and remains a Member of the Editorial Advisory Boards of this and the journals *Environmental Pollution, Land Contamination and Reclamation, Environmental Geochemistry and Health, Agrochimica, Pedosphere* and the *Journal of Environmental Sciences (China).*

In October 2008 Professor Baker was awarded the Milton Gordon Award for '*a distinguished career in teaching, research, and applications of phytoremediation*.'

Dr. Nelson Marmiroli, *Professor, University of Parma*

Phytotechnologies: How Basic Science Meets Technology

BIOGRAPHY

Prof. Dr. Nelson Marmiroli obtained his degree in Biological Sciences in Italy at the University of Parma in 1971. His career developed rapidly through positions of Research Assistant, Associate Professor, and Full Professor at the Universities of Parma, Udine, Lecce, Bologna, Verona, and Chicago. Since 1995, he is stably at the University of Parma, as Full Professor and Head of the Department of Life Sciences, with teaching activities in the fields of Environmental Biotechnology, Genetic Engineering, Functional Genomics and Systems Biology. He is Director of the National Interuniversity Consortium for Environmental Sciences. From the beginning his studies' main research interest has been in the genetic and molecular bases of genotype-environment interactions. Topic addressed with different organisms (plants, crops, microorganisms) and in several contexts: temperature response, drought response, metal contamination, phytoremediation and other applications of phytotechnologies. In recent years, the research has been enlarged to encompass human health, genotoxicity, regulation by miRNAs in HIV infection, allergies, metabolic diseases. A novel focus is now on the genotoxic and metabolic effects of nanoparticles and nanomaterials, from yeast to plants and to human cells.

Dr. David Tsao., Executive Director, The Central New York Biotech Accelerator

The Challenges We Face Now

BIOGRAPHY

Dr. David Tsao is the Americas Technology Manager for the Remediation Engineering & Technology group in BP's Remediation Management function at their Naperville, IL office. He is responsible for a team of technical specialists coordinating, developing, and implementing the technical aspects of clean up strategies for a broad range of BP sites. David also has responsibility for evaluating and minimizing the potential environmental impacts of new BP biofuel products and activities associated with unconventional energy sources. He is a three-time chemical engineering graduate of Purdue University (B.S., M.S., Ph.D) where his eas of research included plant biotechnology, pharmaceutical production, and plant production for space (NASA) applications. Upon graduating, David came to work for Amoco where he specialized in the remediation of gasoline oxygenates and the use of phytotechnologies for remediation and prevention. He remains personally active in bioremediation, phytotechnologies, wetland technologies, and ecosystem restoration. Furthermore, David actively participates in the development of these natural-based technologies, establishes regulatory guidance on their use, and teaches these technologies through the Interstate Technology and Regulatory Council (ITRC), a U.S. state regulatory association. David also serves on the Board of Advisors for ITRC and is an active, founding member in the International Phytotechnologies Society.

Dr. Lee Newman, *Associate Professor, SUNY College of Environmental Science and Forestry*

What Does the Future Hold

BIOGRAPHY

Dr. Newman is an Associate Professor of Plant Biotechnology at the State University of New York College of Environmental Science and Forestry. Her work has included the genetic engineering of plants for increased tolerance to heavy metal stress and increasing degradation of organic compounds, uptake and degradation of chlorinated solvents and aromatics, fuel additives, pesticides, energetic compounds, and nitrogen reduction in soil and groundwater; and has included a variety of trees, herbaceous plants and grasses. In addition to the laboratory work, she has worked on the installation of a number of phytoremediation sites. Dr. Newman is also working with NASA to develop hyperspectral imaging technologies to determine plant exposure to environmental contaminates and is doing research on the use of endophytic bacteria to increase plant growth for biomass and agricultural production. Dr. Newman's most recent area of research is the toxicological study of nanoparticles in the environment, and how crop plants respond to exposures to a range of nanoparticles. Work also includes the impact of nanoparticle accumulation on insects that might feed on exposed plants, and the potential for the particles to move through the food chain. Dr. Newman is co-Editor in Chief for the International Journal of Phytoremediation; founding member and currently Immediate Past President of the International Phytotechnology Society; founding member of the Northeast Phytotechnology Society; and Scientific Advisory Board member of the Association of Environmental Health Science. In the past five years, Dr. Newman has given over 50 invited talks about her research, including 19 in international venues.

Mini Plenary Speaker Biographies

Douglas J. Daley

Doug Daley is an Associate Professor of Environmental Resources Engineering at State University of New York College of Environmental Science and Forestry in Syracuse, NY. Mr. Daley's experience includes investigation, design and application of green infrastructure, ecological engineering and brownfield redevelopment. Mr. Daley's recent projects include: monitoring and modeling water fluxes in a willow-based landfill cover energy crop system; assessing the effectiveness of intensive green roof and bioretention systems for stormwater management; evaluating food waste recovery for sustainable aquaponics development; and planning strategies for sustainable brownfield reuse and redevelopment. Mr. Daley is Director of the SUNY Center for Brownfield Studies, administrative and technical liaison to the New York Water Environment Association and a registered Professional Engineer in New York State.

Tony Eallonardo

Tony Eallonardo has been performing ecological restoration research, implementation and monitoring for over 10 years in ecosystems ranging from freshwater to saltwater, upland to wetland and open to closed canopy. My current focus is the integration of ecological restoration with the remediation of hazardous waste sites and the incorporation of ecological processes into alternative remediation technologies such as evapotranspiration covers.

Guido Fellet

Dr. Guido Fellet is a Postdoctoral Fellow at the Department of Agricultural and Environmental Sciences, University of Udine. He graduated in Agricultural Science in 2000 and he earned his PhD in 2009 at the University of Udine (thesis title: "Phytoremediation of polluted areas with trace elements: observations on metallophyte spontaneous species and agricultural species"). He has conducted his research within projects on the study of the uptake of pollutants from vehicular traffic to tree and shrub species in the urban environment, PGE accumulation from road traffic in mountain areas and of heavy metals in lagoon environments. During his PhD he spent a research period at the USDA-ARS in Beltsville, MD, USA (tutor: Rufus L. Chaney) where he conducted studies on the accumulation of Ni in hyperaccumulator species.

He is currently doing research on biochar characterization and use for environmental management and is now studying the effects of biochar on heavy metals uptake and bioavailability to plants on polluted sites. He is involved in the Food and Agriculture COST Action TD1107 (Biochar as option for sustainable resource management; Chair of the Action: prof. Bruno Glaser).

Dr. André Gerth

Dr. André Gerth received his degree as Agricultural Engineer at the Department of Tropical Agriculture at the University of Leipzig in 1988. Subsequently, he got his Ph.D. at the University of Leipzig (1992). In 1991, he has founded the biotech company BioPlanta (Leipzig, Germany). Since that he holds the position as managing director. The research and business activities are focussing on the development and the use of bio- and phytotechnologies for treatment of water, soil, and sludge.

Dr. Gerth manages and coordinates international projects in Latin America (Peru, Mexico and Chile), Vietnam, China, Hungary and South Africa which deal with passive biological water treatment using Constructed Wetlands, recultivation of brownfields as well as land farming (use of energy crops).

In 2012, BioPlanta was consolidated with Vita 34 and Dr. André Gerth starts his carrier as chief executive officer of Vita 34. Since that BioPlanta is the biotech branch of Vita 34 concentrating on R&D and environmental engineering.

Dr. André Gerth is currently vice-president of the International Phytotechnology Society.

Dennis Hazel

Dennis Hazel is an Extension Specialist and Associate Professor in the Department of Forestry and Environmental Resources at North Carolina State University. His current areas of responsibility include technology and policy development for woody-biomass based renewable energy, forest health and productivity, wildlife research, and Christmas tree production. His degrees are in wildlife biology and forestry. Much of his current work is focused on the potential of fast-grown trees species for site remediation and production of energy feedstocks.

Tomas Macek

Born 1951 in Prague, Prof. Tomas Macek obtained his Master degree at the Faculty of Food and Biochemical Technology, Institute of Chemical Technology in Prague in 1976. He then worked at the Institute of Organic Chemistry and Biochemistry, Czechoslovak Academy of Sciences, with interests ranging from enzyme immobilisation to whole cells, from natural product formation by plant tissue cultures to biotransformation of organic compounds. He obtained his PhD in 1983. His experience abroad includes a year in Biological Research Center in Szeged, Hungary (1977/78), and together with his wife Martina stays at Universite de Picardie, Amiens, France (1993/94), Utah State University, Logan, USA (1995/96) and the Federal Agricultural Research Center in Braunschweig, Germany (1997/98). Since the early nineties he has been working on preparation of genetically modified plants, with concentrated efforts on phytoremediation. In the last decade his research included plant-microbe interaction within rhizoremediation, exploitation of metagenomics for bioremediation and studies of plant enzyme effectors. Since 2010 he became full professor of biochemistry at the Department of Biochemistry and Microbiology of the Faculty of Food and Biochemical Technology, ICT Prague, which is his present address. Within the last 23 years he closely cooperated in all these topics with his wife Prof. Dr. Martina Mackova, who passed away in August 2012.

Heather Henry

Since 2006, Heather Henry has been a Program Administrator for the Superfund Research Program at the National Institute of Environmental Health Sciences (NIEHS) in Research Triangle Park, NC. Her graduate work at the University of Cincinnati involved sustainable remediation of a petroleum landfarm investigating the use of natural revegetation for phytostabilization and phytodegradation of heavy metals and PAHs. During that time, she was an SRP trainee in the University of Cincinnati Superfund Research Program. For her postdoc at the University of Melbourne, she and colleagues worked with native Australian grasses capable of growing on gold mine tailings with high arsenic levels and investigated the role of arbuscular mycorrhizal fungi in the plant's arsenic tolerance. In addition to time in Australia, she spend a college semester abroad in Quito, Ecuador focusing on ethnobotany which involved interviewing medicinal plant vendors at a small farmer's market. Currently, Heather oversees a portfolio of NIEHS grants that span human health toxicology, to risk assessment, to remediation approaches for large centers, small research projects, and small business opportunities.

Kate Kennen

Kate Kennen, principal of Offshoots, Inc. (www.offshootsinc.com) is a registered Landscape Architect based in Boston. Having spent her childhood at her family's garden center in central Massachusetts, Kate is well versed in the plants of the Northeast. She earned her undergraduate degree from Cornell University and Master's Degree in Landscape Architecture with distinction from Harvard University. Kate teaches a research seminar on phytotechnologies for Landscape Architects with Niall Kirkwood at the Harvard University Graduate School of Design and their book 'Phyto for Landscape Design' will be published in Fall 2014.

Mary Beth Leigh

Mary Beth Leigh's research focuses on the microbial biodegradation of organic compounds in the environment, including petroleum, methane, PCBs, and emerging contaminants. Using an array of molecular, culture and biochemical methods, her group is working to understand fundamental biodegradation process and find ways to accelerate them. She is particularly interested in the role of plant secondary compounds in stimulating microbial biodegradation in soil, and in the use of native plants to phytoremediate contaminated sites.

Lou Licht

Louis Licht is founder and president of Ecolotree® Inc. and Ecolofarm®. Since 1990, Ecolotree has designed and installed phytoremediation systems on over 130 sites in 31 states and Europe. These projects use plant root systems to stimulate microbe processes that treat and control contaminants of concern (COC) as defined by the U.S. EPA.

Ecolotree is vertically integrated including: a 110 acre crop farm, 25 acre tree nursery, field agronomy monitoring, project tree planting, on-site maintenance and on-site owner training. In 2013, installed project categories include: landfill leachate irrigated tree covers, landfill perimeters for chlorinated solvent capture, PCB lagoon sediment cleanup, large-scale (6.5 mgd) year-round industrial wastewater treatment, urban swale storm water treatment, and on-site wastewater tertiary treatment for pathogen and nutrient removal. Education included:

The University of Iowa, Iowa City, IA: Ph.D. – Civil& Environmental Engineering, 1990
Oregon State University, Corvallis, OR:M.S. - Agricultural Engineering & Econ, 1978
Iowa State University, Ames, IA: B.S. - Chemical Engineering, 1973

Lou grew up on an Iowan family farm with cattle, hogs, dairy, corn and soybeans. Before Ecolotree, Lou worked for CH2M Hill, Inc. (Corvallis, OR), Proctor & Gamble (Green Bay WI) & E.I. DuPont (Wilmington DE).

Currently, Lou is adjunct professor in Civil/Environmental Engineering at The University of Iowa. He participates in design team mentoring, funding research directed to commercial phyto implementation and providing graduate students internship work experience. He is on the advisory boards for Biological/Ecological Engr., Oregon State University, Corvallis OR and Center for Global and Regional Environmental Research at The University of Iowa.

Yongming Luo

Prof. Yongming Luo is the director of the Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences (YICCAS). His research interests mainly focus on soil pollution and remediation, including phytoremediation and bioremediation. He has more than 30 years of experience in fundamental and applied researches in the areas of soil chemistry and remediation sciences and technologies with more than 300 (co-)authored scientific papers and 10 books and book chapters. He has also obtained 11 patents in China. In the last decade, he has headed more than 20 large (inter)national multidisciplinary research projects which includes 4 projects of international cooperation with the UK, the Netherland, Australia and Japan, funded by Ministry of Science and Technology of China (MOST), National Natural Science Foundation of China (NSFC) and Chinese Academy of Science (CAS).

Michel Mench

Dr. Michel Mench is a senior scientist of the French National Institute for Agricultural Research (INRA) working at the UMR BIOGECO INRA 1202, University Bordeaux 1, Talence, France. He is graduated in Agronomy & Environmental sciences from the National Polytechnic Institute of Lorraine, Nancy, France (PhD 1985) focusing on trace elements and rhizosphere. Upon graduation, he moved to the INRA Agronomy Unit of Bordeaux for working on trace elements in the rhizosphere, food safety, and management of plant exposure to trace elements. He was involved since 1992 in the characterization and phytomanagement of contaminated sites. Since 2003 he joined the UMR BIOGECO and is active in phytoremediation, phytomanagement, production of non-food crops on trace element-contaminated land, and ecological restoration of ecosystem services. He contributed to European projects such as Phytorehab and the ERA-NET Snowman SUMATECS. In January 2011, he started to coordinate a network of 17 field trials within the FP7 European Greenland project, addressing the sustainable phytomanagement of trace element contaminated soils. He is also carrying out researches on molecular mechanisms underlying Cu-tolerance in populations of *Agrostis capillaris*. He was member of the European COST Actions 837 and 859 on phytotechnologies to promote sustainable land use and improve food safety. He is French delegate in the COST Action FA905 (mineral improved crop production for healthy food and feed). He is member of the IPS and of the editorial board of the International Journal of Phytoremediation.

Elizabeth Guthrie Nichols

Elizabeth Guthrie Nichols is an Associate Professor in the Environmental Technology and Management Program, Department of Forestry and Environmental Resources at North Carolina State University. She is also associate faculty with the NCSU Department of Environmental and Molecular Toxicology. She has a M.Sc. and Ph.D. in Environmental Sciences and Engineering from the University of North Carolina at Chapel Hill. She did post-doctoral research in environmental chemistry and biogeochemistry with Dr. Patrick Hatcher (Old Dominion University) at The Pennsylvania State University and The Ohio State University. Her research interests are focused on the use of isotopic tracers to study contaminant C and N cycling in terrestrial and aquatic environments with an emphasis on contaminant cycling and bioavailability in vegetated systems. Her key interests are the protection of surface waters and groundwater quality point and non-point sources. She is interested in use of stable isotopic tracers of vegetation to map the extent of soil and groundwater contamination at various scales from field to spatial analyses. She is also engaged with several funded efforts to address North Carolina's growing need for bioenergy sources, particularly woody biomass production, on liability or marginal lands. She is active in research to use trees as contaminant remediation systems, or phytoremediation. As an educator, she currently teaches undergraduate courses in Environmental Monitoring and Analysis, Environmental Forensics, and the Practice of Environmental Technologies. She teaches a graduate online, distance education course in Environmental Monitoring for NC State's online Master's of Environmental Assessment. She is developing a new distance education curriculum at NC State to provide an online minor in Renewable Energy Assessment for undergraduate majors with two other sister institutions.

Elisha Tel-Or

Dr Tel-Or's current research focuses on the development of biofilter made of dried biomass of the water fern Azolla and its application for heavy metal removal. He is also working on using the biofilter for radioactive metal biosorption, jointly with Soreq Nuclear Center. The filter has demonstrated binding of Cobalt and Cesium from the final wastes of the reactor. Dr. Tel-Or's group is using scanning electron microscopy to localize metal binding groups and is studying the genetics of the protein system. Work is also being done with Cadmium, Mercury, Cobalt and Molybdenum uptake by water lily Nymphae.Additional studies include examining stress tolerance to NaCl in Halomonas.

Liz Rylott

Dr Liz Rylott works at the Centre for Novel Agricultural Products within the Department of Biology at the University of York, UK. Liz graduated with an honours degree in Applied Plant Sciences at the University of Manchester, UK. She then obtained her PhD in Plant Genetics and Biochemistry at the John Innes Centre, UK investigating the mechanism behind C3-C4 intermediate photosynthesis and gaining a broad scientific knowledge in molecular biology and biochemistry. She continued her career as a postdoctoral research fellow in Glasgow, then York studying the control of germination and novel fatty acid production in oilseeds. Liz then focused her studies on understanding the genetic response to and subsequent detoxification of xenobiotics by plants. Alongside this, she is involved in developing plants with enhanced abilities to detoxify pollutants that can be effectively used to remediate environmental pollutants in-the-field.

Tomas Vanek

Tomas Vanek*, RNDr., Mgr., PhD.*,is Head of Laboratory of Plant Biotechnologies IEB ASCR. His scientific interests are connected with natural products chemistry especially with production and biotransformation of biologically active secondary metabolites and degradation (or accumulation) studies of xenobiotics (nitroaromatics, pesticides, toxic metals, radionuclides), including both small and large-scale applications.

His publication activities include over 100 original papers, 1 book, 4 book chapters, 25 invited plenary lectures and 12 patents. He is a member of “Board of Directors” of International Society for Phytotechnologies, member of editorial board of International Journal of Phytoremediation and representative of the Czech Republic in European Plant Science Organization. He is advisor of the Czech Minister of Agriculture.

Timothy Volk

Dr. Timothy Volk has over 25 years of experience working in the fields of forestry, agroforestry, short-rotation woody crops, bioenergy and phytoremediation in the Northeastern United States and Africa. He holds degrees from the University of Guelph (BS (Agr.), Guelph, Ontario) in Natural Resources Management, Cornell University (MS, Ithaca, NY) in Forest Science and SUNY – ESF (PhD, Syracuse, NY) in Forest and Natural Resources Management. He is currently a senior research associate at the State University of New York College of Environmental Science and Forestry (SUNY-ESF) in Syracuse, NY and co-director of
the SUNY Center for Sustainable and Renewable Energy. He is responsible for a series of research projects focused on the development of shrub willow biomass cropping systems as a feedstock for bioproducts and bioenergy and the use of willow as an alternative cover for industrial waste sites. He is also actively involved in research and development of sustainability assessments of bioenergy systems, life cycle assessments of willow biomass crops and woody biomass from forests, assessments of woody biomass availability from natural forests, economic modeling of short rotation woody crops, living snowfences, regional woody biomass resource supplies, and harvesting systems for short rotation woody crops.

Dr. Volk has been actively involved in biomass issues in NY for a number of years including being part of the team that wrote the biomass guidelines for NY's Renewable Portfolio Standard; being the work leader on sustainability assessments and co-leader for the feedstock assessment team for the Renewable Fuels Roadmap and Sustainable Biomass Feedstock Supply for New York project; and a member of the Agriculture and Forestry work group for the NY Governor's Climate Action Planning Team. Dr. Volk was also involved in the development and writing of woody biomass sections of the U.S. Billion Ton Update, which was recently released by the USDOE and USDA. He is the team leader for the willow biomass crop feedstock research and development program under the USDOE Sun Grant feedstock development program.

As co-director of the SUNY Center for Sustainable and Renewable Energy at SUNY ESF Dr. Volk organized a group of faculty from six departments at SUNY ESF to create an interdisciplinary minor in renewable energy and a new major in sustainable energy management. He serves as the curriculum coordinator for the Renewable Energy concentration in the Environmental Science program and Renewable Energy minor at SUNY ESF and is currently teaching courses on Energy Systems and Biomass Energy. He has written or co-authored over 50 peer reviewed publications related to woody biomass over the past 15 years.

Jason C. White

Dr. Jason C. White is the Chief Scientist in the Department of Analytical Chemistry at the Connecticut Agricultural Experiment Station (CAES). Dr. White received his Ph.D. in Environmental Toxicology from Cornell University in 1997. After one year as a Post-Doctoral Associate at CAES, Dr. White joined the Department of Soil and Water in 1998. In 2009, he assumed the Department Head position in Analytical Chemistry. The CAES Analytical Chemistry department provides sample analysis to other state agencies, and also participates as a funded member of the FDA Food Emergency Response Network (FERN). He has active research programs on the plant-nanoparticle interactions and on the remediation of contaminated soils using plants. Dr. White has Adjunct Faculty Appointments at the University of Texas-El Paso, Quinnipiac University, the University of New Haven, and Post University.

He is also serving on the doctoral committees of a one graduate student from Hasselt University in Belgium and two graduate students from the University of Texas-El Paso. He currently resides in Prospect CT with his wife Michelle and six kids (ages 4-18).

Guangshu Zhai

Guangshu Zhai is an Assistant Research Scientist in Department of Civil & Environmental Engineering and IIHR-Hydroscience & Engineering, The University of Iowa. He received his Environmental Science Ph.D. from the Research Center for Eco-environmental Sciences, Chinese Academy of Sciences, China in 2008.

His recent research focuses on phytoremediation of PCBs using poplar plants. The main goal is to elucidate the metabolic pathways of PCBs in plants via the metabolites of PCBs.

PLATFORM PRESENTATIONS

1: Persistent Organic Pollutants

Persistent Organic Pollutants

Taking Advantage of Native Colonizers to Phytoextract of Persistent Organic Pollutants (POPs) at Contaminated Field Sites in Canada

Barbara Zeeb*, RMC; Surmita Paul, RMC; Sarah Ficko, RMC; and Allison Rutter, QUEENS

Since 2010, we have been investigating the potential of native or naturalized colonizer species to accumulated PCBs and DDT into their tissues. Following a survey of 27 species at two sites, we determined that 17 had the potential to extract a similar or greater quantity of PCBs than a known PCB accumulator. Furthermore, when *Chyrsantheum leucanthemum* (ox-eye daisy), *Rumex crispus* (curly dock) and *Solidago Canadensis* L. (Canada goldenrod) were planted in monoculture plots at field sites in southern Ontario, all three species extracted a greater quantity of PCBs per unit area than *Cucurbita pepo* L. ssp. *pepo* even at suboptimal planting densities of 3-5 plants square metre. Large quantities of DDT at Point Pelee National Park in southern Ontario prompted the formulation of a restoration project that includes phytoremediation to investigate the potential of using this technology to assist with remediation within the Park. We surveyed species growing naturally in the Park and compared their ability to take up DDT with the information on PCB uptake from earlier studies. Further, *Schizachyrium scoparium* (little bluestem), *Panicum virgatum* (switchgrass) and *Sporobolus cryptandrus* (sand dropseed) were investigated at three sites in the Park having low (291 ng/g), moderate (5083 ng/g) and high (10192 ng/g) soil DDT levels. Two of these (little bluestem and switchgrass) were identified as potential phytoextractors. When traditional remediation techniques are not appropriate or logistically possible, phytotechnologies may be an asset. Furthermore, by undertaking an *in situ* field study in one of Canada's National Parks, this technology can also be showcased and used as an educational tool.

Keywords: native colonizers, PCBs, DDT, persistent organic pollutants, remediation

*presenting author, Dept. of Chem. & Chem. Eng., 13 General Crerar, Royal Military College of Canada PO BOX 17000 Station Forces, Kingston, ON, CANADA K7K 7B4 613-541-6000 x6713, zeeb-b@rmc.ca

Persistent Organic Pollutants

Plant-mediated Dissipation of Lindane from Soil

P.C. Abhilash*, IESD, Banaras Hindu University; Vishal Tripathi, IESD, Banaras Hindu University; Rama Kant Dubey, IESD, Banaras Hindu University; Nandita Singh, National Botanical Research Institute, Lucknow

Five plant species belong to different use and habit (*Withania somnifera*, *Spinach oleracia*, *Sesamum indicum*, *Vigna radiata* and J*atropha curcas*) were grown in four spiked concentrations (5, 10, 15 and 20 μg g-1) of lindane and were separately harvested based on their growth period. The germination, biomass, chlorophyll, protein, carotenoids content, microbial biomass carbon, lindane concentrations in test plants, residual lindane concentrations in soil and percentage lindane degradation from soil were investigated after every harvesting. The results indicated that high concentrations of lindane delayed the seed germination of all plants. Similarly, there was a significant difference in biomass of test plants and their respective controls ($p < 0.05$). *W. somnifera* exhibited maximum accumulation of lindane in comparison to other test plants. In addition, the dissipation of lindane in test plants soil was more pronounced than the dissipation of lindane in non-vegetated control pots. Similarly, the microbial biomass carbon was significantly higher in test plants soil than vegetated control and non-vegetated control soils. The enhanced dissipation of lindane in vegetated plants than non-vegetated controls is due to the 'plant effect' and 'rhizospheric microbial effect'. The accumulation and dissipation of lindane was linearly related to exposure time and exposure concentrations. The phyotextartion potential of various species was also calculated. All the species can be used for on-site remediation especially *W. somnifera*, *S. indicum* and *J. curcas*. However, suitable harvesting measures are needed to establish a successful rhizoremediation technique.

Keywords: lindane, dissipation, rhizoremediation, onsite remediation

*presenting author, Institute of Environment & Sustainable Development (IESD), Banaras Hindu University, Varanasi 221005, India, Email: pcabhilash@hotmail.com

Persistent Organic Pollutants

Phyto Treatment of Polychlorinated Biphenyls Demonstrated in Laboratory and Field

Yi Liang*, The University of Iowa Department of Civil and Environmental Engineering, Richard Meggo, The University of Iowa Department of Civil and Environmental Engineering, Jerald Schnoor, The University of Iowa Department of Civil and Environmental Engineering, Tim Mattes, The University of Iowa Department of Civil and Environmental Engineering, Louis Licht, Ecoloree, Inc.

Polychlorinated biphenyls (PCBs) pose a potential risk to public health because they are carcinogenic, persistent, and bioaccumulative. Phytoremediation represents a promising PCB removal strategy by rhizosphere processes which happen under the natural conditions. Research at The University of Iowa laboratory shows faster PCB dehalogenation in a switchgrass rhizosphere. After 12 weeks incubation in switchgrass-planted reactors, 18.4% of PCB parent compounds were transformed into less chlorinated congeners. This compares with 8.6% of transformation in unplanted reactors. Higher total bacterial abundance was found in switchgrass planted reactor. The addition of PCB degrader, *Burkholderia xenovorans* LB400, helped to increase total PCB removal from 1% to 6.3%. The LB400 injected reactors were more abundant in *biphenyl dioxygenase* genes and transcripts (*bph*A) - the gene codes for the key enzyme catalyzing the aerobic PCB degradation. This Phyto phenomena may be found occurring in a PCB-contaminated Altavista VA. Lagoon Site, a shallow-rooted native reed canary grass covering 10+% of sediment in dry seasons. A 90-cm sediment plug sample was taken and showed possible effect of rhizosphere-induced PCB reduction. The total Aroclor 1242 was 562 ppm in the bottom 30 cm' layer, 220 ppm in middle 30 cm, and 16 ppm in soil with intimate root contact. An adjacent unrooted 30 cm surface sediment plug had 78 ppm total Aroclor 1242 mass. These combined laboratory and in-situ field data suggest that PCB degradation rate in sediments and soils is increased by presence of intimate root contact.

Keywords: PCB, phytoremediation, switchgrass, *Burkholderia xenovorans* LB400

*presenting author, 4105 Seamans Center for the Engineering Arts and Sciences, Iowa City, IA, 52242 yi-liang@uiowa.edu

Persistent Organic Pollutants

Accumulation and Fractionation of PCBs in Different Parts of Alfalfa (*Medicago sativa L.*)

Xianghui Sun, Institute of Soil Science, Chinese Academy of Sciences; Ying Teng*, Institute of Soil Science, Chinese Academy of Sciences; Chen Tu, Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences; and Yongming Luo, Institute of Soil Science, Chinese Academy of Sciences and Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences

Polychlorinated biphenyls (PCBs) are one of the persistent organic pollutants in the environment. The direct absorption and accumulation by plants is an important step for the transfer of PCBs into human through terrestrial food chain. Better understanding the mechanisms of plant uptake and translocation of PCBs is required for developing an effective phytoremediation. In this study, the accumulation, distribution and chemical speciation of PCBs in different parts of alfalfa (*Medicago sativa L.*) grown in the soil were investigated. The results indicated that the alfalfa could take up and accumulate PCBs from soils through the roots. The roots were the main enrichment parts of PCBs in plant. A chemical sequential extraction procedure was developed to measure the adsorbed, strongly adsorbed and interior absorbed fractions of PCBs in the alfalfa roots. About 78% of the total PCBs were strongly adsorbed in the root tissues, only around 2% of the PCBs absorbed by interior alfalfa roots, and majority of the absorbed PCBs were dichlorobiphenyl (PCB8), indicating that low chlorinated PCB congeners were easily absorbed and transported by the plant tissues. The inhomogeneous distribution of lipids in plant tissues may be an important mechanism for absorbing most PCBs in the root structure or cell walls from the soil.

Keywords: polychlorinated biphenyls, alfalfa, accumulation, chemical speciation

*presenting author, Institute of Soil Science, Chinese Academy of Sciences, Nanjing 210008, China. yteng@issas.ac.cn

Persistent Organic Pollutants

Transgenic Plants in Rhizo/Phytoremediation of Polychlorinated Biphenyls and Evaluation of their Endophytic Microflora

Martina Novakova*, ICT Prague, Veronika Kurzawova, ICT Prague, Martina Chovancova, ICT Prague, Jitka Viktorova, ICT Prague, Petra Prouzova, ICT Prague, Ondrej Uhlik, ICT Prague, Elizabeth Pilon-Smits, CSU Fort Collins, Tomas Macek, ICT Prague

Since polychlorinated biphenyls (PCBs) pose a serious problem as widespread contaminants, there is the need to remediate these contaminated sites. A possible choice for remediation can be the use of plants and microbial consortia. To improve the phyto- and rhizoremediation abilities we designed transgenic plants of *Nicotiana tabacum* containing either (i) bacterial *bphC* gene encoding for 2,3-dihydroxybiphenyl-1,2-dioxygenase cleaving the aromatic ring of dihydroxybiphenyl or (ii) gene for flavonoid-3‘-hydroxylase (*AtF3'H*) from *Arabidopsis thaliana* converting plant indigenous kaempferol to quercetin. The overexpression of flavonoid-3‘-hydroxylase should lead to a higher production of quercetin in plants and consequently to release of quercetin to the rhizosphere, where it should stimulate PCB degradation of rhizospheric bacteria. (i) Transgenic *bphC* plants showed higher decrease of 2,3-dihydroxybiphenyl in sterile liquid media, but this was not achieved when cultivating plants in PCB contaminated soil. To characterize the transgenic plants we currently investigate also their rhizospheric and endophytic microflora. (ii) Our second aim was to prepare and study plants with *AtF3'H*. The cDNA of *AtF3'H* was cloned into pQE30 and in addition, the *AtF3'H* gene with His-Tag was cloned to the plant vector under the control of a root specific promoter. Transgenic plants that produce high amounts of plant secondary metabolites that induce bacterial biphenyl operons may be a promising approach to enhance rhizoremediation efficiency.

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Keywords: PCB, rhizoremediation, phytoremediation, transgenic plants, *Nicotiana tabacum*

*presenting author, ICT Prague, Technicka 5, Praha 6 – Dejvice, Czech Republic, suram@vscht.cz

Persistent Organic Pollutants

Method to assess phytoremediation potential of plants

Bhagya Reddy M*, Fr. Cecil J. Saldanha Centre for Experimental Research in Bioscience, St. Joseph's College Research Center, Nazeeb Imrana, Fr. Cecil J. Saldanha Centre for Experimental Research in Bioscience, St. Joseph's College Research Center, Nayeem Ullah Khan, Fr. Cecil J. Saldanha Centre for Experimental Research in Bioscience, St. Joseph's College Research Center

Phytotoxicity and phytoremediation potential are important in crop plants like maize. The present study aims at developing a method to assess these two biochemical parameters. In the field, mature leaves of maize are known to metabolize methyl parathion (MP). A way to assess phytoremediation potential would be to isolate enzymes of *p*-nitrophenol (PNP) and MP metabolism. However germination and growth studies in petridish cultures are used to determine phytotoxicity of these pesticides. The study has also revealed some interesting results with respect to phytotoxicity and phytoremediation potential when monocot crop plant maize is compared with a dicot weed *Amaranthus spinosus* L. The present paper reports these important characteristics of two plants studied. The phytotoxicity of these compounds is as follows: In maize, inhibition of secondary roots is seen in the presence of methyl parathion. Phytotoxicity studies revealed that both MP and PNP are not toxic to maize even at seedling level. So it is concluded the phytoremediation potential for maize for PNP and MP is 100%. Since growth is stimulated it is surmised that phytoremediation potential of maize is due to presence of enzymes of metabolism of xenobiontics. We have demonstrated the activity of PNP-hydroxylase in crude preparations from maize leaves. A similar study in dicot, *Amaranthus spinosus* L. uses transpiration as tool to assess phytotoxicity. For estimating phytoremediation potential the pollution tolerance index in this plant has been calculated (11.11%).

Keywords: phytoremediation, maize, Amaranthus, MP, PNP

*presenting author: 10, 4th cross, Kumaraswamy layout, opposite Dayananda Sagar College, Bangalore-560 078, India. nayeem65@hotmail.com

2: Constructed Wetlands

Constructed Wetlands

Experimental Study of Flow patterns through aquatic vegetation

Desmond Ofosu Anim*, College of Environment, Hohai University, Nanjing 210098, China, College of Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; Yiping Li, Key Laboratory of Integrated Regulation and Resource Development on Shallow Lakes Ministry of Education, College of Environment, Hohai University, Nanjing 210098, China

Aquatic vegetation in riverine ecosystems is important because of its complex interaction with the surrounding flow which affects other physical and biological processes. Even though there are numerous studies investigating flow-vegetation patterns, their practical application is still rare. In this study, ideal laboratory condition experiments are used to explore the flow patterns as it passes through a merged layer of aquatic vegetation of different plant height and density in an open-flume channel. A 3D Acoustic Doppler Velocimeter (ADV) is employed to measure an instantaneous time-average velocity and turbulence at various positions. A data set of mean velocity and turbulence intensity profiles is evaluated and a detailed description of the flow patterns is reported. From the experimental results, the mean velocity profiles can be separated in three layers: the lower, middle and upper layer and a composite flow pattern characterized by multiple inflection points and velocity spikeswere observed. Turbulence intensity is nearly constant within lower layer and increases substantially from the middle to the upper layer with increasing plant stem width. Generally the flow patterns changes significantly at the middle layer where mass and momentum exchange occurs. The vegetative roughness coefficient increased with increasing vegetation density. These findings will prove useful in various rivers engineering application such as maintaining riverine ecological integrity and restoration of water systems and in understanding transport and mixing processes.

Keywords: aquatic vegetation, open-channel flume, flow, turbulence, velocity

* Anim Desmond Ofosu - College of Environment, Hohai University, Nanjing 210098, China.Tel: +86-15895984009, desofosa@gmail.com

Constructed Wetlands

Dewatering and Treatment of FishfarmSludge in Vertical Flow TreatmentWetlandsPlantedWithMacrophytes

Anne-Laure Biang*, IRBV; Margit Koiv, IRBV ; Vincent Gagnon, IRBV ; Yves Comeau, Polytechnique Montréal ; Jacques Brisson, IRBV.

The issue of handling fish farms' waste has not yet been addressed with success and remains a huge economic and environmental challenge. Two key elements that require attention are nitrogen and phosphorus. Regarding specifically fish farm activities, the amount of pollution associated with these elements rate: 100-150 g/d of ammonium nitrogen and 20-60g/d of total phosphorus per ton of fish produced.

As a solution, we assessed the use of vegetated treatment wetlands (vertical flow drying beds). The remarkable objective of our experiment is to be attentive to the whole process behavior not only along the summer as a VFTW, but also through Canadian winter as a sludge drying bed.

The experimental pilot was implanted within the fishfarm in the vicinity of Montreal (Quebec, CANADA). The unit of a mesocosm is made of a 1m high PVC column of 60cm diameter. Twelve of them were filled with four layers of gravel with a decreasing size from the bottom to the top of the column. Three different plant species were tested through this assay: Cattail (Typhaangustifolia), Canadian native common reed (Phragmitesaustralis subsp. americanus) and exotic common reed (Phragmitesaustralissubsp.australis). Each sp. was planted in four replicates as a monoculture within a column.

The results of this on-site experiment not only confirmed the excellent efficiency of VFTWs on pollutant removal, but likewise helped emphasize the crucial performances for sludge dewatering and mineralization during winter period.

Keywords: treatment wetlands, drying bed, Phragmites, Typha, winter.

* Anne-Laure Biang, 4101 Sherbrooke Est, Montréal, Québec H1X 2B2
anne-laure.biang.nzie@umontreal.ca

Constructed Wetlands

Field Assessment of A Constructed Wetland Used for Slag Leachate Remediation

James G. Hunter*, Morgan State University; Dong Hee Kang, Morgan State University

During construction of an embankment and overpass on I-65 in Hobart, IN, approximately 60,000 metric tons of slag was used as transportation support material. Sometime after construction, leachate began to emerge periodically from the embankment. The resulting reaction stems from under-weathered, unweathered slag interacting with runoff and a possible perched groundwater table within the embankment. This leachate is considered objectionable by Indian Department of Environmental Management (IDEM) and has forced Indian Department of Transportation (INDOT) to develop a remedial action. The use of constructed wetlands was seen as a viable treatment option for this water pollution problem. A zero effluent, field-scale retention wetland was constructed to treat the slag leachate and to reduce total sulfur, high pH, and other pollutants, along with limiting open water exposure. Results indicate that reduction of sulfate, metals, total dissolved solids, other inorganic constituents, and buffering of pH, can be achieved by the abiotic and biotic processes of the engineered wetland system, under low flow conditions and long retention times. The distinct advantage of such an approach is that it is far less expensive than other clean-up alternatives.

Keywords: Wetland, Slag, Sulfur, Leachate, Zero effluent

* James G. Hunter, 1700 E. Cold Spring Lane, Baltimore, MD james.hunter@morgan.edu

Constructed Wetlands

Performance and Mechanisms of Contaminant Removal from Wood Leachate in a Treatment Wetland

Wendong Tao*, College of Environmental Science and Forestry, State University of New York

Wood in outdoor applications is usually treated with preservatives to retard wood decay. Alkaline copper quaternary (ACQ) is one of the most commonly used wood preservatives. Its primary biocide, copper, can leach out of ACQ-treated wood by rainfall in outdoor storages and uses, posing risks to aquatic ecosystems and water uses. This study explored the performance and mechanisms of copper removal in a pilot-scale treatment wetland that received leachate from both ACQ-treated and untreated red pine lumber piles. The wetland was located in Jamesville, New York. It was packed with cobbles, pebbles, and rubber mulch from bottom to 34 cm thick, and planted with common reeds (*Phragmitesaustralis*). The wetland was operated in a batch mode with cycle lengths varied with the dates of actual leaching events from July 2010 to January 2013. Leachate from treated and untreated wood typically has high concentrations of chemical oxygen demand as well. The average concentrations of the wood leachate were 434 µg/L copper, 147 mg/L chemical oxygen demand, and 6.2 µg/L arsenic. The wetland removed 69% copper, 48% chemical oxygen demand, and 54% arsenic on average. Plant height, stem diameter and number of stems were recorded 3-5 times per year to estimate plant biomass. Above- and below-ground plant samples were collected along with rubber mulch. Cu assimilated to plant tissues and adsorbed to rubber mulch will be determined to assess the treatment mechanisms.

Keywords: chemical oxygen demand, copper, *Phragmitesaustralis*, treatment wetland, wood leachate

* Wendong Tao, 1 Forestry Drive, Syracuse, NY. wtao@esf.edu

Constructed Wetlands

Aerobic Cometabolism of a Suite of Chlorinated Hydrocarbons in Flow-Through Wetland-Plant Mesocosms

Garrett Struckhoff*, California State University, Fullerton; Ke Qin, Katherine Gingandet, AbinashAgrawal, Wright State University

Research has shown that providing microorganisms a substrate such as phenol, methane, or ammonia may yield rapid cometabolic degradation of recalcitrant chlorinated chemicals. However, those studies were performed in microcosm-scale reactors, typically with only microbes present. This study evaluated the overall degradation potential of chloroform, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene, tetrachloroethene, and 1,2-dichloropropane (henceforth, CAHs) in a flow-through system with wetland plants. 5-Liter pore-volume reactors were either planted with *Scirpusatrovirens* or left unplanted. Methane was added to the deoxygenated feed solution at concentrations ranging from 0 – 50% of saturation. While methane cometabolism was a primary degradation pathway, other potential fate pathways existed in the planted reactors. Plant root exudates provided a carbon source for cometabolism while phytovolatilization of contaminants into the atmosphere was another potential fate. Methane concentration was varied and CAH phytovolatilization rates were measured to tease out the overall role of each of the three fate mechanisms.

Oxygen, methane, TIC, and CAH concentrations were monitored over time and with height in the reactor. Decreasing concentrations of CAHs was used as the metric for experimental success. At the effluent, at least 29% removal was observed for all CAHs with three of them exceeding 58% removal.

The plant shoots were enclosed in Tedlar® bags to allow monitoring of atmospheric CAH transfer. Using the rate of accumulation in the headspace, an estimate of the volume within, and the known influent concentration; it was determined that as much as 21% of the total contaminant added was transferred to the atmosphere.

Keywords: wetlands, chlorinated, cometabolism, methane, phytovolatilization

* Garrett Struckhoff, California State University, Fullerton, Civil and Environmental Engr., 800 N. State College Blvd, Fullerton, CA 92831 (957) 278-8079, gstruckhoff@fullerton.edu

Constructed Wetlands

Remediation of Shallow Groundwater Impacted With Chlorinated Ethenes Utilizing an Engineered Wetland

Kilcoyne, Richard F., Atlantic Richfield Company; Sauer, Nancy E.*, URS Corporation

In 1998, an engineered wetland to remediate shallow groundwater impacted with chlorinated ethenes (trichloroethene (TCE) and daughter products) was constructed at a rural site in Michigan. At the time of construction, the influent TCE concentration was approximately 2,000 ug/l. An NPDES permit was issued by the regulatory agency.

The treatment wetland was constructed by lowering the existing surface grade. The wetland is divided by soil berms into four cells with a total surface area of 3.6 acres. An excavated trench filled with gravel and cobble sized material was constructed on the up-gradient side of the cells to provide a preferential pathway for groundwater to passively flow into the wetland cells. The outflow discharges at the NPDES permitted outfall.

Operational issues identified during early operation of the system included muskrat infestation, hydraulic short-circuiting and elevated vinyl chloride concentrations. Optimization of the system included:

- Removal of deep trenches and addition of cross berms to eliminate hydraulic short circuits and decrease muskrat habitat
- Installation of a “muskrat exclusion barrier” on the perimeter fence and muskrat trapping
- Installation of recirculation system to address low flow

System optimization has resulted in year-round treatment of the chlorinated plume by the engineered wetland system. The engineered wetland has been successful in reducing chlorinated ethenes and meeting design goals and permit requirements. The engineered wetland has also developed into an ecologically diverse system that provides habitat for a variety of wildlife.

Keywords: Treatment Wetland, Chlorinated Ethenes, TCE

* Sauer, Nancy E., 1375 Euclid Ave., Suite 600, Cleveland, Ohio 44115 nancy.sauer@urs.com

3: Production of Biofuels and Plant Biomass

Production of Biofuels and Plant Biomass

Utilization of energy plants for phytoremediation purposes – its working?

Tomas Vanek* IEB ASCR, Petr Soudek IEB ASCR, Sarka Petrova IEB ASCR, and Radka Podlipna IEB ASCR

Phytoremediation has been defined as the use of green plants and their associated micro-organisms, soil amendments and agronomic techniques to remove, contain or render harmless environmental contaminants. From the available decontamination approaches phytoremediation represents typical in situ biological treatment, which main advantage is that it allows soil to be treated without being excavated and transported, resulting in potentially significant cost savings. Based on the research during recent years, phytoremediation technology is a promising cleanup solution for a wide variety of pollutants and sites, but it has its limitations.

For large-scale applications of phytotechnologies, there is necessary to select such type of plant, which is available (seeds, seedlings) in required quantity and, for economical application, respective agrotechnique is available. From this point of view, crop plants seems to be most effective solution. To avoid potential food chain contamination during both phytoextraction and phytostabilization, non-food crop plants can be promising solution of above mentioned problems.

Other promising approach is utilization of energy plants for such purposes. This approach can be very effective for sustainable land management as well as for maintainig of agricultural activities in contaminated areas. We test energy crop potential for such purposes in Czech Republic in period 2009 -2012 with promising results.

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Keywords: plant biomass

* Tomas Vanek, Laboratory of Plant Biotechnologies, Institute of Experimental Botany AS CR, v.v.i. Rozvojová 263, 165 02 – Prague 6, Czech Republic, vanek@ueb.cas.cz

Production of Biofuels and Plant Biomass

A Biorefinery for the Production of Biogas from Aquatic Plants and Biodiesel from Microalgae and Wastewater.

Eugenia J. Olguín*, INECOL; Omar Castillo, INECOL; Héctor Hernández, INECOL; Mariana Robles, INECOL; Erik González-Portella, INECOL; Anilú Mendoza, INECOL; Karla Tapia, INECOL; Víctor Javier Hernández, INECOL; Gloria Sánchez, INECOL; Flor Cuervo, UAM-Iztapalapa.

Recently, simultaneous production of biofuels within a Biorefinery utilizing wastewater has been pointed out as a more appropriate approach to attain a sustainable and cost-effective process. Within this context, a multi-national project coordinated by INECOL in México has been implemented. The aim of the project is to develop a pilot plant for the production of biogas from aquatic plant biomass and biodiesel from microalgae biomass utilizing wastewater. The first Unit Operation of the Biorefinery is a Phytofiltration system of the water from an urban polluted river (Sordo River) in which the water is treated by *Pistia stratiotes* and the harvested biomass serves for the production of biogas in a second Unit Operation. The annual productivity of the plant was 27.5 $g \cdot m^{-2} \cdot d^{-1}$ during most of the year and it was not significantly affected by the season or the water's quality. Phosphate removal was 96.25 and ammonia nitrogen removal was 98%, COD removal was 78% after 25 days. In a two phase anaerobic reactor, a yield of Volatile Fatty Acids (VFA) of 2235.2 $mg \cdot L^{-1}$ and a yield of 0.282 g VFA g-1 SV after 6 days were observed during the first phase (hydrolysis and acidogenesis), when using ruminal liquid and the pH was controlled daily at 6.3. In a third Unit Operation for the production of rich lipid microalgae, *Neochloris oleoabundans* was cultivated using anaerobic effluents from pig waste. So far, results from the various Unit Operations are promising and work is in progress to optimize plant and microalgae biomass.

Keywords: urban polluted river, phytofiltration, biofuels, phytoremediation, green algae

* Eugenia J. Olguín, Instituto de Ecología A. C. (INECOL), Antigua carretera a Coatepec 351, El Haya, Xalapa, Veracruz, México, C.P.91070, eugenia.olguin@inecol.edu.mx

Production of Biofuels and Plant Biomass

Extreme expression of cellulases in poplar

Tom Sniffen, Syracuse University, Caitlin Phalen, Syracuse University, Heather Coleman*, Syracuse University

Plant cell walls provide a source of fermentable sugars for the production of ethanol and other biofuels. There are, however, several roadblocks to developing an economically viable cellulosic ethanol process based on biochemical conversion. One of the largest challenges is the cost associated with the production of cellulolytic enzymes responsible for reducing the highly crystalline cellulose and hemicelluloses to fermentable sugars. The aim of this research is to verify and enhance a transgenic technology which allows for the inducible, high level accumulation of enzymes *in planta*, and to assess the benefits of cellulase expression through this system on the efficiency of hydrolyzing cellulose to fermentable sugars. Inducible expression of cellulolytic enzymes *in planta* provides the opportunity to significantly reduce the cost associated with biomass conversion to fermentable sugars. The advantages of this system include the local availability of cellulases produced in the leaf tissue of the same plants being utilized for biofuels production, ease of collection and processing of the leaf tissue, and the potential to directly add ground leaf material without having to carry out complex enzyme extractions. This work will be carried out in poplar, a promising biomass feedstock for cellulose conversion to fermentable sugars. It is a non-food crop which grows rapidly on marginal lands less suited for agriculture, and unlike current feedstocks it is not restricted to seasonal harvest patterns. Production of cellulolytic enzymes in stable transgenic poplar brings together the benefits of *in planta* enzyme expression with an ideal biomass crop for cellulosic biofuel production.

Keywords: Biofuels, poplar, cellulases, *in planta* expression

*Heather Coleman, Syracuse University, hcoleman@syr.edu

Developing *Camelina sativa* as a dedicated Biofuel Crop: Enhanced Oil Yield and Quality via Manipulating Triacylglycerols Synthesis Pathway

Om Parkash Dhankher*, University of Massachusetts; Sudesh Chhikara, University of Massachusetts; Parisa Akabri, University of Massachusetts; Kenny Ablordeppey, University of Massachusetts; Bibin Paulose, University of Massachusetts and Danny Schnell, University of Massachusetts

Liquid transportation fuels based on plant seed oils have tremendous potential as an alternative to petroleum-derived fuels. However, current biofuel production relies on crop species that have been bred for food oil production (e.g. soybean, sunflower and brassica). To avoid competition with food oil production, it is paramount to develop dedicated non-food crops for biofuel production that can be cultivated in a broad geographic range. *Camelina sativa* has been proposed as an ideal non-food crop for biofuel production. Further increase in seed oil yield by manipulation of the triacylglycerol (TAG) biosynthesis pathway and by increasing the flux of carbon from increased photosynthesis to TAG synthesis will make this crop highly profitable. In seeds, TAG is synthesized from glycerol-3-P and fatty acids through the sequential activities of the glycerol-3-P acyltransferase, lysophosphatidic acid acyl transferase and diacylglycerol acyltransferase. Overexpression of enzymes that catalyze the synthesis of glycerol backbone and conjugation of fatty acids to glycerol backbone appear to be a promising target for increasing TAG accumulation. Therefore, to further increase the oil contents and seed yield, we targeted the overexpression of genes including glycerol-3-phosphate for use as the backbone for TAG synthesis and genes involved in acylation of fatty acids in the downstream process for TAG synthesis. By overexpression of these genes involved in TAG synthesis either singly or in combination, we are able be increase up to 35-50% seed yield and 15% enhancement in oil content in the seeds. Steps to further improve the seed and oil yield in *C. sativa* are in progress.

Key words: *Camelina sativa*, triacylglycerols, biofuels, transgenic plants, carbon flux

* Om Parkash Dhankher, Stockbridge School of Agriculture, University of Massachusetts, 230 Stockbridge Rd, Amherst, MA 01003;

The Effects of Planting Density and Fertilization rate on Phytoextraction of Trace Elements Using Sunflower as Bio-fuel Plants

Dongwook Kim*, Seong Min Woo, Jaehong Yim, Phygen Inc., Korea; Jae Young Kim, Seoul National University, Korea; Jung-Kul Lee, Kunkuk University, Korea; Seokho Jung, Hyunjae Kwon, Jongchan Park, Chowon Kim, Eunjin Lee, Bomin Kang, Gwang Hyun Han, Chungbuk National University, Korea

Various plants were reported that can extract trace elements from soils. Plant biomass and trace elements accumulation are crucial factors for phytoextraction. Sunflower (*Helianthus annuus* L.) is not a hyperaccumulator but a prevalent phytoremediation plant since it is easy to be cultured and it produces comparatively large biomass. A field study using sunflower was conducted to evaluate the optimal planting density and fertilization rate to investigate the possible application of phytoremediation. The filed soil was contaminated by various trace elements (3.7 mg/kg Cd, 70.3 mg/kg Cu, 14.6 mg/kg Pb, 133.4 mg/kg Zn, 6.0 mg/kg Ni, 2.6 mg/kg As). Sunflower used in this study has been proved a suitable candidate for phytoextraction and bio-fuel plants. The field experiments were set up at three different planting densities (20, 40, 60cm) and three different fertilization rates (no fertilization, recommended allowance level, double recommended allowance level). Results showed that there was no significant difference between the chemical properties of soil and cultivation method. However, total nitrogen content in each plant was increased by higher fertilization level and planting density. The plant biomass per unit area was great in allowance fertilization level and 20cm planting density treatment (49.8t/ha). The concentrations of trace elements in the plants generally increased with the increasing addition of fertilizer. As a result, optimal sunflower cultivation method in trace elements contaminated area is 20cm of planting density and over the recommended allowance level of fertilizer in this study.

Keywords: phytoextraction, planting density, fertilization rate, trace elements, sunflower

* Dongwook Kim, 73 Oncheonbuk-ro, Yuseong-gu, Daejeon, 305-301, Korea
dwsoil88@daum.net

Production of Biofuels and Plant Biomass

Salinity Gradients and Biomass Accumulation in a Planted Willow Ring

Jaconette Mirck*, ADC AAFC, Bill Schroeder, ADC AAFC

Many small wetlands are scattered across the Canadian Prairies. These wetlands are commonly referred to as sloughs or potholes. They are often surrounded by a ring of phreatophytic shrubs, of which willow is the dominant genus. Therefore these sloughs are also called willow rings. Traditionally many farmers have removed the willow rings from their agricultural lands to facilitate farming activities. Research indicates that the native willows in the willow rings used to play an important role in the hydrology of the prairies. Willows and other vegetation in the willow ring play an important role when it comes to shallow ground water flow. The removal of the willow rings potentially results in the presence of high salinity levels close to the surface, because the elimination of transpiration by the willows will cause an increase in shallow groundwater flow.
A willow ring was replanted in the spring of 2011 around a slough that had signs of surface salinity. Survival measurements were carried out in the fall of 2011 and correlated with Electromagnetic-Induction Meter (EM38) readings. In addition, soil moisture and lysimeter samples were collected and ground water levels were monitored. The objectives of this study were to 1) assess the effect of salinity levels on growth and vice versa, and 2) assess the effect of growth on groundwater levels, soil moisture and soil water salinity levels.

Keywords: soil moisture, soil water, wetlands, woody crops

*Jaconette Mirck, No 2 Government Road, Indian Head, SK jmirck@gmail.com

4: Plant Associated Microorganisms

Plant Associated Microorganisms

Plant-associated bacteria: An important key to a successful application of phytoremediation

Nele Weyens*, Hasselt University; Panos Gkorezis, Hasselt University; Daniel van der Lelie, Research Triangle Institute, NC, USA; Safiyh Taghavi, Research Triangle Institute, NC, USA; Jaco Vangronsveld*, Hasselt University

Phytoremediation is a promising technology: driven by solar energy, plants are able to pump contaminations to their rhizosphere and even take them up. In the rhizosphere and during its transport throughout the plant, the present plant-associated micro-organisms can take care of the organic contaminant's degradation.

Successful application of phytoremediation was demonstrated in 2 field cases (BTEX and oil contamination). On these sites, poplar trees were planted in the contamination plume and groundwater concentrations and possible evapotranspiration to the atmosphere were monitored. Despite the above mentioned and other successful field applications, phytoremediation is not yet applied on a large scale due to some constraints. At first, plants should tolerate the occurring contaminant levels. Further, the degradation capacity of the plant-associated micro-organisms must be high enough to prevent phytotoxicity and evapotranspiration. To solve these constraints, a diversity of interesting characteristics of plant-associated bacteria can be exploited.

The availability/uptake of many organics can be stimulated by bacteria producing e.g. surfactants, siderophores and organic acids. Bacteria with the appropriate degradation pathway(s) can strongly improve the degradation efficiency.

In a third field case, this concept of endophyte-enhanced phytoremediation was successfully applied on a TCE-contaminated site. Poplar trees were planted and *in situ* inoculated with TCE-degrading endophytic bacteria. Three months after inoculation, a 90%-reduced TCE evapotranspiration was observed. Further investigations revealed that this reduction was not only achieved by an enrichment of the inoculated strain, but also by transfer of the degradation genes from the inoculated strain to bacteria from the natural abundant population.

Keywords: field application, organic contaminants, poplar, plant-associated bacteria

* Nele Weyens, Hasselt University, Agoralaan building D, 3590 Diepenbeek, Belgium, nele.weyens@uhasselt.be

Effect of plant growth promoting bacteria, *Pseudomanas putida* UW4 on plant biomass yield and phytoremediation of mixed PAH-contaminated soil

Seniyat L Afegbua*, Lesley Batty and Joanna Renshaw; University of Birmingham, United Kingdom.

PGPB are extensively used to improve plant growth, yields and plant stress tolerance in agriculture but their application to phytoremediation of contaminated land is a relatively new remediation technology. Few studies have reported the effect of PGPB on plant tolerance and growth in the presence of organic toxicants and metals. This study was designed to assess the effect of PGPB; *Pseudomonas putida* UW4 on plant growth, biomass yield and phytoremediation efficiency in two different treatments; phenanthrene, fluoranthene and benzo[*a*]pyrene (PAH) and phenanthrene, fluoranthene and benzo[*a*]pyrene, and heavy metal; lead (PAH+HM). Alfalfa, tall fescue, ryegrass and mixed plant (ryegrass and tall fescue) were used for this study. Results showed differences in plant growth and biomass yields in both PAH (shoot; 8-20% and root; 11- 65%) and PAH+HM (shoot; 11-65% and root; -4 - 101%) treatments with PGPB although the yields were not significantly different. PGPB addition had stimulatory effect and in a few cases had no effect or an inhibitory effect on PAH dissipation. An increase in PAH dissipation from treatments with PGPB addition was observed especially for fluoranthene in some treatments. PAH dissipation was significantly different only for phenanthrene, fluoranthene and benzo[*a*]pyrene dissipations of the Alfalfa-PAH treatment and for phenanthrene and fluoranthene of the PAH+HM treatment. Other treatments had comparable PAH dissipations despite PGPB addition. Successful colonisation and survival of PGPB, plant type, plant-microbe interaction amongst other factors are important in improving plant biomass for an enhanced phytoremediation. PGPB addition may improve biomass yield without necessarily enhancing phytoremediation.

Keywords: PAH remediation, plant growth promoting bacteria

* Seniyat L Afegbua, University of Birmingham, United Kingdom seniyat.larai@googlemail.com

Plant Associated Microorganisms

Shifts in Naphthalene-Degrading Bacterial Communities Associated with Rhizoremediation of Diesel

Kelly McFarlin*, University of Alaska Fairbanks; Catherine Glover, University of Alaska Fairbanks; Anastasia Kottara, Institute of Chemical Technology; Ondrej Uhlik, Institute of Chemical Technology; Mary-Cathrine Leewis, University of Alaska Fairbanks; Mary Beth Leigh, University of Alaska Fairbanks

Rhizoremediation relies on plants to biostimulate the microbial degradation of pollutants, but little is known about how degradative microbial populations respond to rhizostimulation. Outdoor pot experiments coupled with DNA-based stable isotope probing (SIP) were applied to investigate how *Salix alaxensis* (felt leaf willow) affects naphthalene degrading populations during rhizoremediation of diesel-contaminated soil. The concentration of diesel range organics (DRO) was monitored in planted and unplanted (control) treatments, with and without fertilizer addition, over a summer in interior Alaska. SIP incubations were performed in microcosms constructed from rhizosphere soils to identify and compare ^{13}C-naphthalene-utilizing bacteria in the willow-planted versus unplanted (control) treatments. Sequencing of 16S rRNA genes from SIP incubations was conducted to identify bacterial populations associated with naphthalene biodegradation and inputs of fertilizer. Terminal restriction fragment length polymorphism (T-RFLP) of ^{13}C-DNA was also performed to further examine the diversity of bacteria that derived carbon from naphthalene. In the pot study, growth of *S. alaxensis* resulted in the greatest loss of DROs. A variety of bacteria active in naphthalene utilization were identified using 16S rRNA sequencing of ^{13}C-DNA. T-RFLP profiles of naphthalene-utilizing bacterial populations suggest that the presence of willow and/or fertilizer may have enhanced the growth of a particular bacterial taxon, and cluster analysis showed that active populations clustered separately for control compared to willow samples. This research suggests that *S. alaxensis* can be a useful plant for rhizoremediation of diesel-contaminated soil and that growth of this willow altered the structure and/or composition of naphthalene-utilizing populations relative to that of unplanted soil.

Keywords: Rhizoremediation, Diesel, Alaskan Willows, SIP, T-RFLP

*Kelly McFarlin, 982 N. Koyukuk Dr., 101 Murie Bldg., Fairbanks, AK kmmcfarlin@alaska.edu

Plant Associated Microorganisms

Interaction of Cd/Zn hyperaccumulating plant (*Sedum alfredii*) and rhizosphere bacteria on metal uptake and removal of phenanthrene

WC Li*, The Hong Kong Institute of Education and Croucher Institute for Environmental Sciences; and Minghong Wong, Croucher Institute for Environmental Sciences and Zhejiang Agriculture and Forestry University

The effects of bacteria (*Burkholderia cepacia*) on plant growth, metal uptake, tolerance index and phenanthrene degradation by a hyperaccumulating plant (*Sedum alfredii*) were investigated. It was found that inoculation of bacteria did not enhance plant growth and metal uptake; while both metal translocation factor (up to 84% for Cd and 42% for Zn) and tolerance index (up to 23.2% for shoot and 72% for root) were significantly increased. In addition, inoculation of bacteria also alleviated the reductions of bioaccumulation factor and phytoextraction efficiency of As, Cu and Zn with the increasing proportions of polluted soil applied, while they were even increased for Cd and Pb (up to 31.2 and 124%, respectively). Up to 96.3% of phenanthrene was removed in the treatment with both plant and bacteria at the end of the experiment. A positive correlation between metal and P accumulation in plants was observed, it is suggested that high P uptake is directly involved in metal detoxification and leading to an increased P requirement. With the assistance of bacteria, *S. alfredii* could be able to withstand higher metal concentrations and it could also provide a practical tool for phytoremediation.

Keywords: *Burkholderia cepacia*, PAHs, Phytoextraction efficiency, Tolerance index, Translocation factor

* WC Li, The Hong Kong Institute of Education waichin@ied.edu.hk

An *Arabidopsis* model for seed endophyte-assisted plant growth upon Cd exposure

Sascha Truyens*, Hasselt University CMK; Sofie Thijs, Hasselt University CMK; Nele Weyens, Hasselt University CMK; Jaco Vangronsveld, Hasselt University CMK

Endophytic bacteria live inside plant tissues without harming their host. They can have plant growth promoting abilities, such as the production of plant hormones, or possess contaminant sequestration/degradation mechanisms. Enrichment of these endophytes in the plant after inoculation can enhance growth and reduce phytotoxicity in plants growing on contaminated soils, which is important in improving the efficiency of phytoremediation. Especially seed endophytes can play a significant role in this process: they are transferred from generation to generation and can possess characteristics which are important for germination and seedling development.

We used the model plant *Arabidopsis thaliana* to demonstrate that transgenerational exposure to Cd induces shifts in the seed endophytic population. Some bacterial genera were plant-dependent, as they occurred in both Cd-exposed and non-exposed control seeds, while others seemed to be contaminant-dependent. Also phenotypic differences occurred in the endophytes: metal tolerance and 1-aminocyclopropane-1-carboxylate deaminase activity were more often found in bacteria isolated from seeds of Cd-exposed plants compared to non-exposed controls. Preliminary screenings indicated that several of the isolated bacteria were able to promote growth of *Arabidopsis* after inoculation in the presence of Cd. However, these results were not consistent during subsequent experiments. The inoculation success seems to be correlated with the growth stage of the bacterial strain at the time of inoculation. Growth curves of several endophytic strains were established and motility in different growth stages was compared. Colonizing capacity and plant growth promoting abilities of the strains in their different growth stages were compared after inoculation of *Arabidopsis*.

Keywords: endophytes, cadmium, phytoremediation, plant colonization

* Sascha Truyens, Agoralaan building D, 3590 Diepenbeek, Belgium,
sascha.truyens@uhasselt.be

5: Aquatics and Metal Remediation

Aquatics and Metal Remediation

Phytoremediation in China: Advances and Perspectives

Yongming Luo*, Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences; Chen Tu, Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences; Ying Teng, [2]Institute of Soil Science, Chinese Academy of Sciences

Remediation of the polluted farmland soils and industrial sites is receiving extensive attention for a safe food and residence, human health and social stability in nowadays China. Due to its low-cost and environmental friendly, phytoremediation has been considered to be an emerging green and sustainable technique for soil remediation. Recently, there have been significant improvements and achievements in phytoremediation, including plant species scanning, innovative remediation techniques, post treatments of plant biomass, demonstration in field scale, and practical applications. This paper reviews in general the research, development, application and remained problems of phytoremediation for solution of contaminated soils and sites with heavy metals and organic pollutants in China during last decade. A major soil remediation program approved recently by the Ministry of Science and Technology of China is introduced. Future perspectives are also proposed, aiming at a promoted application of phytotechnologies for remediation of the soil environment, and eventually for protection of food safety and human health in the nation.

Keywords: soil contamination, polluted site, soil remediation, phytoremediation, phytotechnology

* Yongming Luo, 17 Chunhui Road, Laishan District, Yantai, Shandong Province, China. ymluo@yic.ac.cn

Aquatics and Metal Remediation

Plant Based Technologies for the Removal of Toxic metals and Organic Pollutants

Elisha Tel-Or, R.H. Smith Institute for Plant Sciences, Faculty of Agriculture, The Hebrew University of Jerusalem, Rehovot, Israel

We have recently improved and optimized the technology for biosorption of toxic metals. The model we established aims to remove lead ions from aquifers, at a site used for over 60 years for arms production. This program, developed in collaboration with the Israel Water Authority, demonstrated hyper purification of lead by one step filtration, through biomass of the aquatic ferns *Salvinia* and *Pistia,* yielding a solution containing less than 10 ppb (parts per billion) Pb^{++}. The column, containing 100-400 grams of biosorbent, treated up to 400 ml of lead polluted effluents per minute. The biosorbent demonstrated up to 30% Pb^{++} lead a of the plant biomass. A second system, a hydroponic bioreactor for the removal of atrazine by *Sorghum* plants, was set in a greenhouse, where plants grown on a feeding layer, developed a massive root system in containers of 12 liter atrazine solution.

The system was optimized to remove 30 mg atrazine per liter within 2-4 weeks when the system was aerated. The removal of atrazine was effective in the presence of 12 g/L NaCl. Radiolabelled atrazine demonstrated the accumulation of the herbicide and its breakdown products in the plants.

Keywords: lead biosorption, *Salvinia* and *Pistia* biofilter, atrazine active removal, *Sorghum* hydroponic reactor.

* Elisha Tel-Or, The Hebrew University of Jerusalem, Rehovot 76100, Rehovot, Israel
telor@agri.huji.ac.il

Aquatics and Metal Remediation

Phytoremediation of Chromium-VI Contaminated Groundwater by a Rhizofiltration Pilot

Eleni Dimitroula, TU-Crete; Eleni Manousaki, TU-Crete; Nicolas Kalogerakis*, TU-Crete

Over the past 10 years, a serious chromium pollution problem has been identified in Asopos river basin situated in the region of Central Greece as Cr(VI) concentrations in drinking water often exceed the acceptable drinking water criteria and the groundwater concentration is often above the national environmental quality standard (EQS). As part of EU's LIFE-Environment project "CHARM", a rhizofiltration pilot has been constructed for Cr(VI) removal from groundwater and is being tested at a common location (with 3 other pilots) in the Inofyta area of the Region of Central Greece. The pilot uses four different halophytic plants (*Halimione portulacoides, Tamarix gallica, Juncus acutus and Sarcocornia perennis*) to treat about 10 m^3/day of chromium-contaminated groundwater in the range 50 to 150 ppb. As a complement to the pilot unit in the field, small scale pilots were constructed at the TU-Crete campus where the same plants were grown on tap water contaminated with Cr(VI) in concentrations 0, 50, 200 & 500 ppb (as $K_2Cr_20_7$). The rate of chromium removal from the contaminated influents has been measured in all systems through monitoring of the inlet, outlet and rhizosphere concentrations of heavy metals in order to establish the efficiency of the constructed wetland. In addition, Cr accumulation in the plant tissue was monitored through analysis of the plant parts. Moreover, the physiological responses of the employed halophytes to chromium VI were examined through measurements of chlorophyll content, biomass, water content and oxidative stress.

Keywords: chromium VI, groundwater remediation, rhizofiltration, halophytes

* Nicolas Kalogerakis, Department of Environmental Engineering, Technical University of Crete, Polytechneioupolis, 73100 Chania, Greece, nicolas.kalogerakis@enveng.tuc.gr

Aquatics and Metal Remediation

The Study on Cadmium Accumulation by *Eichhornia crassipes* under water pollution conditions

Olga Shuvaeva*, Institute of Inorganic Chemistry, Siberian Branch of Russian Academy of Sciences; Ludmila Belchenko, Novosibirsk State University; Tamara Romanova, Novosibirsk State University

Phytoremediation technology is an effective sustainable, energy and cost economic method of environment clearing due to the plants ability to hyper-accumulation of the pollutants. The floating macrophyte water hyacinth, *Eichhornia crassipes (EC)*, is applied most often to waste waters purification. In contemporary literature many studies are focused on the actual metals uptake by plants but sufficiently less is known about the process of their transport and transformation inside the plant's tissue, but there is a great need in strengthening knowledge concerning the mechanism of the process, which would help to manage it. The goal of the present investigation was to study the process of metal's bioaccumulation by *EC* when exposed to cadmium with an emphasis on the mechanism of penetration of pollutant within the plan and its fate during accumulation act. As a result it was shown that at the first stage cadmium sorption on the surface of the roots takes place at that metal is mainly localized in rhizodermis, then the pollutant penetrates into the tissues of the stem according to its translocation factor with the formation of the complexes rich in cysteine. It has been assumed that flavonoids perform an intermediate role in the accumulation process, taking part in the transport and combat an oxidative stress.

In contrast to the traditional black-box approach, detailed investigations of pollutant transport and distribution in plant tissues have given sound understanding of the phytoremediation phenomenon. Such advancements could provide a basis for future improving the efficacy of the biological remediation processes.

Keywords: water contamination, bioaccumulation, pollutant transport in plant

* Olga Shuvaeva, Academician Lavrent'ev Prospect, 3, Novosibirsk, 630090, Russia, olga@niic.nsc.ru

Aquatics and Metal Remediation

An *Engineered_Phytoremediation*^{SM} System for Hydraulic Control of Brackish Groundwater

Ron Gestler*, TEA, Inc.; Frank Manale, TEA, Inc.; Edward Gatliff, Applied Natural Sciences, Inc.; Joanne West, Dow Chemical Canada ULC

A mitigation strategy using *Engineered_Phytoremediation*^{SM} was evaluated in 2011 and 2012, which is to be employed in early 2013 to achieve hydraulic control for a brackish aquifer containing elemental mercury and methyl mercury. The aquifer is located under a landfill that was closed with a high-density polyethylene cap and a cover of clean soil. An *Engineered_Phytoremediation*^{SM} system will be utilized to minimize the impact to the landfill cap and cover, while allowing the designer to direct root growth and subsequent water-uptake from a targeted horizon. In 2011, a pilot study was established to evaluate the potential for using halophytic vegetation to achieve hydraulic control of brackish groundwater. This study involved the screening of 13 species of halophytic and other salt tolerant vegetation under on-site brackish groundwater conditions. Eighty individual lysimeters were established (8 replicates for 7 species and 4 replicates for 6 species), and monitored for water use and viability. The results of this evaluation are expected to be employed in early 2013 to achieve effective hydraulic control of the brackish aquifer. Results from the pilot study allowed the selection of optimal plant species and final design of the *Engineered_Phytoremediation*^{SM} system required to achieve the desired hydraulic control necessary to prevent the migration of contaminated groundwater. The results of the pilot study as well as details of the construction of the *Engineered_Phytoremediation*^{SM} system at the landfill will be discussed.

Keywords: *Engineered_Phytoremediation*^{SM}, phytoremediation, hydraulic control, landfill, brackish aquifer

* Ron Gestler, 901 Loveridge Road, Pittsburg, CA gestlerr@teainconline.com

Root Growth Responses, Mercury in Cell Walls and Protoplasts and Mercury-binding Thiol Peptides of Water Hyacinth under Mercury Exposure

Juliana Janet M. Puzon, Institute of Biology, College of Science, University of the Philippines;
Ma. Catherina V. Fajardo, Institute of Biology, College of Science, University of the Philippines;
Gilda C. Rivero*, Institute of Biology, College of Science, University of the Philippines,

Water hyacinth [*Eichhornia crassipes* (Mart.) Solms.] plants were grown in Hoagland nutrient solutions with 0.00, 0.01 and 1.0 mg L^{-1} $Hg(NO_3)_2$ for 3 days. Growth responses of the roots in terms of biomass, length and number were evaluated. These parameters were not significantly affected by mercury treatment levels, as well as age of the roots. The analysis of Hg content through inductively coupled plasma-atomic emission (ICP-AES) spectrometry revealed the localization of Hg in the cell walls and protoplasts of young and mature roots of Hg-exposed *E. crassipes* plants. Generally, mature roots took up greater amounts of Hg compared with the young roots. Mercury accumulation of isolated cell walls and protoplasts were also examined through a dialysis membrane set-up and subsequently the Hg contents of cell walls and protoplast were determined through ICP-AES. Accumulation of Hg in these sub-cellular components was significantly affected by the level of Hg treatment, length of time exposure, and the age of the roots. Moreover, the levels of thiol-containing Hg-binding peptides in gel filtration fractions detected through 5,5'-dithiobis(2-nitro-benzoic acid) (DTNB) assay increased in the root protoplasts as a result of Hg exposure. The capacity of the roots to maintain normal growth and the compartmentalization of Hg ions in the cell walls and protoplasts, as well as the increased production of Hg-binding thiol peptides, constitute the tolerance mechanisms of *E. crassipes* roots under Hg stress. The results of this study lend support to the efficacy of *E. crassipes* as a mercury phytoremediator.

Keywords: water hyacinth, mercury, root growth, mercury-binding peptides

* Gilda C. Rivero, Institute of Biology, College of Science, University of the Philippines, Diliman, Quezon City gcrivero2013@gmail.com

6: Explosives

Plant community response to explosive soil contamination and potential for airborne detection.

Stephen Via*, VCU; Julie Zinnert, ERDC; Donald Young, VCU

Soils contaminated with explosive compounds are a persistent global problem. The two most common explosive compounds in the environment are 1,3,5-Trinitroperhydro-1,3,5-triazine (RDX) and 2,4,6-Trinitrotoluene (TNT). Both induce varying stress responses in plants depending on the species, environmental factors, and plant age. Both RDX and TNT can inhibit germination, seedling establishment, and overall adult plant growth and function but effects vary among species. Thus, age based impacts have the potential to alter plant community composition. We evaluated woody and herbaceous composition on a privately owned minefield to explore the hypothesis that explosive soil contamination impacts plant community composition. Species composition was determined in areas of known RDX, TNT, and Comp B (a mixture of RDX and TNT) contamination. Reference plots outside of the contamination areas were also included. Species diversity and richness were calculated and principal components analysis (PCA) was used to determine community shifts. Field work was coordinated with airborne LiDAR and hyperspectral imagery. Community composition in contaminated areas was different from reference areas. Greater differences were seen in the herbaceous community while the woody community was relatively stable overall. The difference in communities indicated that presence of soil contamination has an impact on plant communities and changes are detectable via remote sensing. Such community shifts may remain after the contaminant thus having long lasting and far reaching ecosystem impacts.

Keywords: soil contamination, plant community, remote sensing, hyperspectral, LiDAR

* Stephen Via, Dept. of Biology, Virginia Commonwealth University, 1000 W. Cary St., Richmond, VA 23284. viasm@vcu.edu

Explosives

Phytodetoxification of the environmental pollutant 2,4,6-trinitrotoluene (TNT) is mediated by glutathione transferases

Elizabeth L. Rylott*, University of York; Vanda Gunning, University of York; Helen Sparrow, University of York; Kyriakos Tzafestas, University of York; and Neil C. Bruce, University of York.

The explosive 2,4,6-trinitrotoluene (TNT) is a major military pollutant. The presence of this toxic and highly persistent pollutant, particularly at military sites and former manufacturing facilities, presents various health and environmental concerns. Due to the chemically resistant structure of TNT it has proven to be highly recalcitrant to biodegradation by microorganisms. TNT is phytotoxic, and plants have only a limited innate ability to cope with the levels of TNT found at contaminated sites. To understand the biochemistry behind the detoxification of TNT *in planta*, we initially conducted a microarray using *Arabidopsis thaliana* (Arabidopsis) as a model species and identified two GSTs, GST-U24 and U25, that are specifically upregulated in response to TNT exposure. Following expression in *Escherichia coli*, and purification, we assayed these GSTs for activity towards TNT. Characterization revealed the formation of three TNT glutathionyl-products, one of which was produced in equimolar quantities with the release of nitrite. The removal of nitrite from the TNT molecule results in a product that is potentially more amenable to subsequent mineralization than transformed-TNT products. Furthermore, when GST-U24 and GST-U25 were over-expressed constitutively in Arabidopsis, the transformed lines exhibited a significantly enhanced ability to withstand and detoxify TNT; properties that could be exploited for the *in planta* detoxification of TNT in the field.

Keywords: 2,4,6-trinitrotoluene, TNT, glutathione transferase, GST, detoxification

* Elizabeth L. Rylott, CNAP, Department of Biology, University of York, Wentworth Way, York, YO10 5DD, UK. liz.rylott@york.ac.uk

Explosives

Grasses and bacteria joining forces: bioaugmented rhizoremediation with common bent for clean-up of 2,4,6-trinitrotoluene

Sofie Thijs*, Hasselt University; Nele Weyens, Hasselt University; Sascha Truyens, Hasselt University; Panos Gkorezis, Hasselt University; Jan D'Haen, Hasselt University; Robert Carleer, Hasselt University; Jaco Vangronsveld, Hasselt University

In situ bioremediation of nitro-aromatic 2,4,6-trinitrotoluene (TNT)-contaminated sites often faces limitations such as phytotoxicity and poor degradability. Grasses are well suited for rhizoremediation of shooting fields because they have an extensive root system and do not hinder military activities. However TNT has been shown to induce oxidative stress and plants have only limited organic degradation abilities. Therefore, we investigated soil and plant-associated bacteria of a TNT-contaminated site. Cultivable strains were isolated and molecular characterised. The intention was to identify TNT-metabolising bacteria that stimulate plant-growth. Next, effectiveness of bioaugmentation with a TNT-degrading consortium was evaluated *in vitro* with tobacco (*Nicotiana tabacum*) and in a rhizoremediation soil-column experiment with bent grass (*Agrostis capillaris*). We isolated from the TNT-contaminated soil a consortium of TNT-metabolising strains expressing nitroreductases. *Klebsiella sp.* tolerated up to 113 mg l^{-1} TNT and we observed vesicle formation as protective mechanism. Plant-experiments *in vitro* demonstrated that inoculation with the consortium significantly enhanced growth of TNT-exposed tobacco. In the soil-column experiment, bacteria affected TNT-levels significantly. The extractable TNT-content in the rhizosphere soil of common bent inoculated with bacteria decreased by more than 70 % after 28 days in comparison to only 25 % for the controls. Moreover, roots of inoculated grasses were larger and denser than the non-inoculated controls, which can be advocated to the role of bacteria in the rhizosphere. No TNT could be observed in the shoots, rendering the grass suitable for several uses. Overall, this indicates that bioaugmented rhizoremediation with common bent is promising for clean-up of TNT.

Keywords: 2,4,6-trinitrotoluene, bioaugmented rhizoremediation, common bent grass

* Sofie Thijs, Hasselt University, 3590 Agoralaan building D, campus Diepenbeek, Belgium sofie.thijs@uhasselt.be

Proteomic profiling of Vetiver grass (*Chrysopogon zizanoides*) under 2,4,6 Trinitrotoluene (TNT) stress

Padmini Das*, Montclair State University; Venkataramana R. Pidatala, Michigan Technological University; Dibyendu Sarkar, Montclair State University; and Rupali Datta, Michigan Technological University.

One of the major challenges in successful application of phytotechnology to remediate 2,4,6-trinitrotoluene (TNT) is its phytotoxicity, as TNT is commonly found in high concentrations in contaminated military sites. Our earlier studies have shown that vetiver grass is an ideal plant for TNT phytoremediation. The current study is the first attempt to investigate the changes in the proteomic profile of a plant under TNT stress. Vetiver plants were grown in a plant growth chamber in nutrient media with varying concentrations of TNT (0,25,50,100 mgL^{-1}) for 10 days. Although the plants appeared healthy, significant biomass reductions ($p<0.001$) were found in all the TNT treated plants. However, a significant ($p=0.03$) reduction in total chlorophyll content was observed only in 100 mg L^{-1} TNT treatment. Total proteins in the root decreased significantly ($p=0.0003$), but no significant ($p>0.05$) change was noted in the shoot. Root proteins showed a significant ($p<0.0001$) negative correlation (r=-0.97) with TNT and followed a linear (R^2=0.94) decrease with increasing TNT concentrations in solution. Classical 2-DE-gel-electrophoresis was conducted to separate the proteins. Gel analyses using the Image Master Platinum 6.0 software (GE healthcare Lifesciences) showed that 20 protein spots had a minimum of two fold change in their intensities (6 upregulated and 14 downregulated), compared to the control gel. Protein spots with a minimum two fold change were excised from the gel for MALDI-TOF analysis. Comprehensive understanding of changes in the proteomic profile will provide important clues to the mechanism of stress response and the tolerance in vetiver grass.

Keywords: Vetiver, TNT, Proteomics, Chlorophyll, Proteins.

* Padmini Das, 40, Brookdale Gdns, Apt C, Bloomfield, NJ 07003, dasp1@webmail.montclair.edu

Explosives

Rapid Phytoforensics for Energetics

Yuan Yuan, Joel G. Burken*, Ruipu Mu, Adcharee Karnjanapiboonwong, Xiaojing Wang, Honglan Shi, Yinfa Ma, Missouri University of Science and Technology

Military munitions and propellants are common contaminants from years of production, distribution and use. Fugitive contaminants are difficult to detect in groundwater and the potential remediation efficacy relies on accurate delineation of the contaminated areas. As vascular plants extract water and nutrients from the subsurface, they also accumulate trace contaminants from their surroundings. Novel sampling and analytical approaches can access this data which exists *in planta*.

To analyze plant samples, LC-MS-MS analytic methods for Perchlorate, PETN, HMX, RDX, TNT, 2A-DNT, nitroguanadine, and DNAN were developed with a total run time of < 6 minutes and method detection limits (MDLs) are the lowest yet reported for many compounds, down to 20 ng/l. Novel centrifugation techniques extract the transpiration tissues stream fluids mechanically without any solvents and extracts are filtered injected directly, compared to traditional solvent extractions and condensing.

The advantages and disadvantages of the rapid plant sampling methods will be discussed. Plant tissue - subsurface concentration relationships of Perchlorate, PETN, HMX, RDX have been shown to be essentially linear for the rapid centrifugation methods, revealing potential for using a variety of plant species for phytoforensic analysis. Different plant species had widely varying subsurface: plant relationshps. By developing novel plant sampling methods and advancing analytical methods, subsurface contaminant delineations may be conducted without ever breaking the surface, thereby minimizing concerns of UXOs in preliminary site investigations. These methods are also very rapid, inexpensive and minimally invasive to property or to the ecosystems we are working to protect.

Keywords: Energetics, Explosives, Phytoforensics, phytomonitoring, uptake.

* Joel G. Burken, Missouri University of Science and Technology, Environmental Engineering, Butler Carlton Civil Engineering Hall, Rolla, Missouri USA, burken@mst.edu

7: Health and Exposure Risk

Health and Exposure Risk

Use of plants as passive samplers for volatile organic compounds (VOCs) in indoor environments

Bill Doucette*, Utah Water Research Laboratory; Todd Wetzel, Utah Water Research Laboratory

Volatile organic compounds (VOCs), including many with documented short- and long-term adverse health effects, can enter indoor environments through internal (i.e. paints, paint strippers, fuels, cleaning supplies, pesticides, building materials, adhesives) and external sources (i.e. vapor intrusion from contaminated groundwater). Indoor air concentrations of VOCs vary widely, but concentrations of most VOCs are consistently higher indoors than outdoors. Typical approaches used to sample indoor air include evacuated canisters and sorbent tubes. The use of ornamental plants has been suggested as a simple, unobtrusive, aesthetically pleasing, and cost effective method for sampling and purifying indoor air. The waxy surface of the leaves has the potential to provide a good surface for the passive capture of VOCs. However, the efficiency and kinetics of capture have not been well characterized. To investigate the potential use of plants as indoor air VOC samplers, three types of studies were performed. The first consisted of monitoring air and plant concentrations over time after a controlled release of several VOCs into a residential building containing several plant species. The second study used a flow-through glass and stainless plant growth chamber to evaluate the relationship between air and plant leaf VOC concentrations. The third study used a headspace approach to measure equilibrium leaf-air partition coefficients. Good correlations between the leaf and air concentrations observed in the three different studies suggest that plant leaves can be used to monitor indoor air concentrations of VOCs.

Keywords: indoor air, VOCs, plants, sampling, leaf-air partition coefficients

* Bill Doucette, Utah Water Research Laboratory, Utah State University, 8200 Old Main Hill, Logan, UT 84322-8200 william.doucette@usu.edu

Health and Exposure Risk

Bioaccessibility and bioactivity of selenium from Se-hyperaccumulated cereal crops: a step towards their use for developing natural Se supplements

Tejo Prakash Nagaraja*, Thapar University, Patiala, India

Changes in topographical features and leaching/erosion processes have played an important role in the development of seleniferous soils in the different parts of the world. Our studies during last few years on seleniferous soils between Nawanshahr-Hoshiarpur prefectures in North-West India indicated excessively high selenium content in irrigation water (160-200 □g l^{-1}) and soil (2.8-6.9 □g g^{-1}). The studies carried on crops such as wheat, rice, mustard and maize cultivated in the region showed significantly high levels of accumulation in edible crop produce ranging 670 □g g^{-1} in mustard to 38 □g g^{-1} in maize. The quantification of Se in various matrices was carried out using neutron activation analysis and ICP-MS. The observations seem to be highest ever reported in food grains for human consumption. Speciation of bioavailable selenium, using reverse-phase and cation-exchange HPLC (ISS, Rome), in wheat showed dominant (70%) presence of SeMet followed by traces of $SeCys_2$ and MeSeCys. Further search, using LC (HILIC)-ESI-Orbitrap MS(/MS) (University of Pau, France), for lower molecular weight compounds indicated presence of unique selenosugar complexes. Bioaccessibility of Se under *in vitro* gastric, gastrointestinal and large-intestinal sections showed significant transformation of SeMet to variety of accessible and volatile selenium compounds hitherto less reported. Preliminary observations on the potential of Se rich wheat extracts indicated expression of anti-inflammatory cascade when influenced by pro-inflammatory agents under *in vitro* conditions. An ultimate goal of using Se rich crop produce for nutraceutical and health related applications are being envisaged and attempted using variety of approaches.

Keywords: Selenium, seleniferous soils, cereals, bioaccessibility, bioactivity

* Tejo Prakash Nagaraja,School of Energy and Environment, Thapar University, Patiala, India.
ntejoprakash@thapar.edu

Effect of agricultural residues as soil amendments on cadmium accumulation in rice plants

Parinda Suksabye*,Suan Dusit Rajabhat University; Dian Siswanto, Brawijiya University; Prapai Dhurakit, King Mongkut's University of TechnologyThonburi; Apinya Pimthong, King Mongkut's University of Technology Thonburi; Sirikan Maneesuwannarat, King Mongkut's University of Technology Thonburi; Paitip Thiravetyan, King Mongkut's University of Technology Thonburi.

The cadmium contamination in rice is a major problem in Mae Sot District, Tak Province, Thailand. The effect of agricultural residues as soil amendments on reducing cadmium accumulation in rice plants was investigated. The rice plants were grown in cadmium-contaminated soil withvarious agricultural residues such as saw-dust fly ash (SDFA), rice husk fly ash (RHFA), bagasse fly ash (BGFA),corncobs (CC),coir pith (CP), and orange peels (OP) at 1% w/w. The concentration of cadmium-contaminated soil ranged from 290-377 mg Cd/kg soil. The rice plants were harvested after 60 days in order to determine the cadmium distribution in the roots,shoots and grains. The results showed that saw-dust fly ash (SDFA) could reduce cadmium accumulation in the roots, shoots and grains of rice more effectively than other agricultural residues. The cadmium concentration in the roots, shoots and grains was 821.40, 32.42 and 12.48 mg Cd/kg dry weight, respectively, when adding saw-dust fly ash as an amendment. The rice plants grown in cadmium-contaminated soil without the addition of agricultural residues had higher cadmium concentrations in the roots, shoots and grains than with the addition of saw-dust fly ash. Agricultural residues can also enhance the dry weight of plants. In addition, agricultural residues themselves can be used as adsorbents to adsorb soluble cadmium from cadmium-contaminated soil. To confirm the mechanism of adsorption between cadmium and agricultural residues, SEM/EDX and desorption study were analysed.

Keywords: cadmium, rice plants, agricultural residues, soil amendments

* Parinda Suksabye, 295 Ratchasima Road, Dusit, Bangkok, 10300, Thailand
parin_bung@yahoo.com

Health and Exposure Risk

Regulation of cadmium accumulation and bioaccessibility in wheat

Renuka Sankaran*, Department of Biological Sciences, Lehman College, City University of New York

Cadmium (Cd) is an important trace metal contaminant found in at least 60% of the sites on the EPA's National Priorities list. In the United States, the main source of cadmium exposure for adults and children is through dietary intake. Fertilized soils in particular, tend to contain four to six times higher cadmium than unfertilized soils. In particular, grain crops such as durum wheat *(Triticum turgidum*) grown in North American soils with naturally elevated cadmium levels tend to accumulate cadmium to levels exceeding international limits for Cd in cereal grains. In order to ensure the safety of durum wheat grown and marketed in these soils, there have been a number of efforts in breeding low Cd accumulating cultivars. Although a number of studies have focused on understanding the mechanism of Cd accumulation in plant foods, there is considerably less information available on the mechanisms that influence the degree of Cd bioaccessibility from cereal grains. The overall goal of this research is to provide information that can be utilized to improve Zn density in seed crops while simultaneously reducing the possible dietary exposure to Cd. The proposed study will use two near isogenic lines of durum wheat which differ 2.5 fold in grain Cd concentrations but are otherwise similar. Specific objectives of this project are to understand the difference in regulation of Cd accumulation in these two lines and to assess the difference between Cd accumulation and bioaccessibility. The results of these studies will be presented.

Keywords: cadmium, zinc, cereals, bioaccessibility, accumulation

* Renuka Sankaran, 250 Bedford Park Blvd West, Bronx, NY 10468
renuka.sankaran@lehman.cuny.edu

Quantifying the Effects of Horticultural Therapy on Spinal Cord Injury Patients

Daniel Collins*, State University of New York-College of Environmental Science and Forestry (SUNY-ESF); Heather Holmes, SUNY-ESF; Lee Newman, SUNY-ESF

Horticultural therapy is the use of therapeutic gardens to promote the mental health and physical recovery of many different types of patients. These gardens are typically designed to be a safe, inviting space, in which the patients can interact with nature, and in some cases used to supplement the current physical therapy the patients are undergoing. We have designed both a therapy garden on the rooftop of the new spinal cord injury wing of the Syracuse Veterans Affairs Hospital, as well as working with care givers to place plants in common areas that overlook the garden and in individual patient rooms. We work to engage patients in the care and upkeep of this garden and with therapists to develop it into a full component of the therapy program. As the study progresses, we will monitor patient vitals, analgesic prescription, time remaining in the hospital, and administer psychological surveys in order to determine how the presence of green spaces, as well as participation in the horticultural therapy program, produces a measurable benefit to patients.

Keywords: horticulture, spinal cord injury, recreational therapy

* Daniel Collins, SUNY-ESF, 1 Forestry Drive, Syracuse, NY 13210 collins.danielb@gmail.com

8: Covers and Stabilization

Covers and Stabilization

Scaling assisted phytostabilization from the greenhouse to the field at the Iron King Mine-Humboldt Smelter Superfund Site

Juliana Gil-Loaiza*, University of Arizona; Scott White, University of Arizona; Jon Chorover, University of Arizona; Raina M. Maier, University of Arizona

Legacy mine tailings are susceptible to wind and water erosion, posing risks to neighboring communities and ecosystems. The Iron King Mine-Humboldt Smelter Superfund Site (IKMHSS) in Dewey-Humboldt, Arizona contains acidic tailings with elevated levels of lead and arsenic (≥ 3000 mg/kg) and high levels of salts (EC 6.5–9 ds/m). Phytostabilization, the establishment of a vegetative cap that does not accumulate metals in shoot tissues, can reduce metal transport and bioavailability. Our objective was to evaluate whether field scale success can be achieved using desert native plants and compost rates from successful greenhouse phytostabilization trials. A study area was established on the IKMHSS site with six treatments and an irrigation system. Tailings were amended with 10, 15, or 20% (w/w) of compost and were direct seeded with native plants (buffalo grass, Arizona fescue, quailbush, mesquite, and catclaw acacia). Controls included composted (15 and 20%) unseeded treatments and an uncomposted unseeded treatment. After 29 months seeded treatments achieved a canopy cover ranging 27% to 52%. No plants grew on unamended tailings. Neutrophilic heterotrophic bacterial counts were 2 to 4 orders of magnitude higher after 26 months compared to unamended control plots. Metal accumulation in plant shoot tissue samples were below Domestic Animal Toxicity Limits. Results show that phytostabilization was successfully scaled from the greenhouse to the field. We will continue to evaluate (i) tailings characteristics to see if they improve over time as a medium for plant growth, and (ii) the long-term potential for plant survival and succession in these tailings.

Keywords: phytostabilization, mine tailings, canopy cover, neutrophilic heterotrophic bacteria, field scale

* Juliana Gil-Loaiza, Department of Soil, Water and Environmental Science, University of Arizona, 429 Shantz Building #38, Tucson, AZ 85721 juligil@email.arizona.edu

Covers and Stabilization

Phytotechnology Cover for Industrial Landfill Closure

Michele Abbene*, Roux Associates, Inc, J. Douglas Reid-Green, BASF Corporation, and Nathan Epler, Roux Associates, Inc.

Roux Associates worked with the BASF Corporation to design and install an alternative landfill cover for a nine-acre industrial landfill at an 80-acre former chemical manufacturing facility adjacent to the Hudson River in Rensselaer, New York. The landfill design consists of multiple soil layers vegetated with a mixture of phytotechnology and indigenous plant species. This presentation will focus on the pre-design activities that were performed to evaluate potential phytotoxicity and bioaccumulation concerns of planting species directly into landfill waste to promote rhizodegradation and phytostabilization of contaminants. Rooting tests were conducted on hybrid poplar and willow cultivars to determine the suitability of the landfill waste and groundwater to sustain plant growth. In addition to performing rooting tests, pilot planting plots were installed in the landfill proper to determine survival in the site-specific environment. Following completion of the pilot tests, plant samples (root, stem, and leaf) were collected and analyzed to evaluate potential contaminant bioaccumulation.

Results demonstrated the ability of the species to stabilize the landfill contaminants and minimize translocation into aboveground portions of the plants. The landfill cover was then subsequently designed to balance the water needs of the various plants with the evapotranspiration requirements to minimize infiltration and demonstrate equivalency with state landfill closure regulations.

The cap vegetation also includes numerous native species to promote ecological diversity and create a valuable wildlife habitat. The project was officially certified by the Wildlife Habitat Council in 2008 as part of the *Wildlife at Work*[SM] and *Corporate Lands for Learning*[SM] programs.

Keywords: phytotechnology, phytoremediation, alternative landfill covers

* Michele Abbene, 209 Shafter Street, Islandia, NY 11749, mabbene@rouxinc.com

Covers and Stabilization

Assessing bacterial colonization of plant roots as a bio-indicator of phytostabilization sustainability using fluorescent in situ hybridization (FISH)

Linnea Herbertson*, University of Arizona; Jon Chorover, University of Arizona; Raina M. Maier, University of Arizona

Phytostabilization of legacy mine tailings is an effective method for reducing heavy metal transport; however, sustainable plant establishment can be challenging due to a predominance of autotrophic bacteria, low pH, poor soil structure, and high metal concentrations in the harsh mine tailing environment. We hypothesize that assessing the bacterial colonization of plant roots will help provide a better understanding of how plants successfully establish in stressful environments like mine tailings. We will use this analysis to identify indicator bacterial populations that help to predict plant health in mine tailings, and therefore, subsequent sustainable phytostabilization. The Iron King Mine and Humboldt Smelter Superfund Site (IKMHSS) in Dewey-Humboldt, Arizona contains acidic mine tailings with high levels of arsenic and lead. In order to identify potential bio-indicators in these mine tailings, this research compares the bacterial colonization of *Buchloe dactyloides* (Buffalo grass) roots from a field study at IKMHSS exhibiting sustained plant establishment to roots of a mesocosm experiment containing IKMHSS tailings with failed plant establishment. Fluorescent in situ Hybridization (FISH) was used to assess bacteria colonization using probes to target Eubacteria, Actinobacteria and Alpha-Proteobacteria. Results suggest that the area of root covered by Eubacteria, the extent of metabolically active bacteria, and the presence of and proportions of Alpha-Proteobacteria and Actinobacteria are all potential indicators of plant health. Increasing our understanding of bacterial colonization of plant roots grown in mine tailings and development of potential bio-indicators for plant health, can help maximize plant establishment and sustainability during phytostabilization.

Keywords:

* Linnea Herbertson, University of Arizona, Tucson, AZ linneah@email.arizona.edu

Covers and Stabilization

Effects of varied N concentration on a variety of willow genotypes.

Farrar Sian*, AFBI, McCracken Alistair, AFBI, Quinn John, QUB

Landfill leachate is an organic contaminant formed from the percolation of rainwater through landfill waste. Disposal of leachate can be difficult and expensive. Willow (Salix spp.) is grown as a source of biomass as a renewable energy fuel. Genotypes for biomass are selected on the basis of their ability to produce high, above ground dry matter yield. Willows take up large volumes of water and are tolerant to many contaminants, making them potentially suitable for the bioremediation of effluents and leachates. The selection of willow genotypes suited for bioremediation may be based on criteria other than biomass yield. Eight willow genotypes were selected from a wider list which had been screened for their response to leachate. These were Olaf, Jorrun, Germany, Endeavour, Nimrod, RR05196, 97111 and 80404 which were irrigated with a range of leachate concentrations based on N content. Plant response was assessed by measuring height, fresh weight, dry weight, root weight, chlorophyll fluorescence, ICP analysis (P,K,Ca,M,S) of stems and leaves, total N and total C of stems and leaves, and soil element analysis. There were significant differences (P=0.05) in height and dry matter yield between genotypes and leachate concentration. . Higher concentrations in the leachates of some elements e.g. K and Mg correlated to higher concentrations in leaf tissue. The ANSWER (Agricultural Need for Sustainable Willow Effluent Recycling) project is part funded by the European Union's European Regional Development Fund (ERDF) through the INTERREG IVA Cross-border Programme, managed by the Special EU Programmes Body (SEUPB).

Keywords: willows, landfill leachate, bioremediation, bioenergy, N loading.

* Farrar Sian, Agri-Food & Biosciences Institute, 18A Newforge Lane, Belfast, UK.
Sian.Farrar@afbini.gov.uk

Covers and Stabilization

Development of an Alternative Vegetative Cover Using Shrub Willows in Central, NY

Timothy Volk*, SUNY ESF; John McAuliffe, Honeywell International; Lawrence Abrahamson, SUNY ESF; Douglas Daley, SUNY ESF; Stephanie Lewis, SUNY ESF; Shun Shi, SUNY ESF

A phased phytoremediation strategy is being used to effectively develop an alternative vegetative cap using shrub willows on former industrial land in Solvay, NY. The substrate in this area is a byproduct of soda ash production using the Solvay process that occurred in the area from 1881 – 1986. This substrate has a high pH, low nutrient content, limited structure and elevated salt concentrations making it a difficult growing environment for plants. The goal of the project is to develop and deploy an effective vegetative cover that will reduce the percolation of chloride salts into groundwater and surrounding surface water and simultaneously produce a source of woody biomass for the production of renewable energy. Several steps were involved in the phased phytoremediation strategy including screening of willow varieties in a greenhouse, small scale field tests of willow varieties on the site, and trials with different locally available organic amendments to create conditions that would support the rapid growth of willows. Over the years the system has been tested and refined. With the proper combination of organic amendments and site preparation, willow production on this site has reached, and in some cases exceeded, levels that have been measured on agricultural soils in the region. The system is now being deployed at the site and through the spring of 2013 about 35 ha are in place. On ongoing program of monitoring, optimizing the system and screening new willow varieties is underway to ensure the long term performance of this vegetative cap.

Keywords: *Salix*, willow biomass crops, phased phytoremediation

* Timothy Volk, 346 Illick Hall, SUNY ESF, Syracuse, NY 13210; tavolk@esf.edu

9: Building Integrated Vegetation

Building Integrated Vegetation

The OnCenter Green Roof:
A Tool for Managing Urban Stormwater

Mallory Squier*, Syracuse University; Cliff Davidson, Syracuse University

Syracuse, New York is one of over 700 communities in the United States with a combined sewer system. Increased disruptions to the natural water cycle from the built environment have resulted in overloaded sewer systems. Neighborhoods throughout the city and Onondaga County have taken a combined approach to the solution, implementing green and gray infrastructure. One green infrastructure project is a 60,000 sq. ft. green roof on the County's convention center, the OnCenter. Estimated to capture 1 million gallons of precipitation annually, this roof was chosen for its size and location in downtown Syracuse. This presentation discusses the types of measurements needed to estimate a water mass balance on the green roof to better understand the role of green roofs in decreasing urban runoff and stress on the sewage treatment system. The water mass balance equation, simplified for a green roof, is as follows: $P - RO - ET = \Delta S$, where P is precipitation, RO is runoff, ET is evapotranspiration, and ΔS is the change in storage, all as equivalent depth of water in the growth medium. The measurements to be conducted in this project will quantify the terms of the water mass balance and demonstrate the behavior of a large extensive green roof under a variety of weather conditions. Real-time monitoring data will be made available publicly via a website, along with educational materials.

Keywords: green infrastructure, urban stormwater, green roof, evapotranspiration

* Mallory Squier, 151 Link Hall, Syracuse University, Syracuse, NY mnsquier@syr.edu

Building Integrated Vegetation

The Use of Native Plants on an Intensive Green Roof: Initial Results

Tim Toland*, SUNY ESF; Donald Leopold, SUNY ESF; Doug Daley, SUNY ESF; Darren Damone, Andropogon Associates

Rooftop environments present challenges due to extreme conditions of heat, insolation, wind, drought, freezing and nutrient stress. Non-native sedums, commonly used for vegetating green roofs, are durable but are of limited ecological value. To enhance ecological value while also meeting sustainability and aesthetic goals, SUNY Environmental Science and Forestry (Syracuse, NY) installed an intensive green roof on the Gateway Center using species native to the eastern Lake Ontario dune and alvar pavement barren communities. These communities are adapted to environments analogous to rooftop settings.

Most species from these communities are not well known and had not been previously used on green roofs. To verify the feasibility of using these species, a pilot study was completed in test plots replicating the installation, establishment and maintenance procedures proposed in the project specifications. Of the 44 species tested, 41 met survival, aesthetic, and growth performance criteria. The consultant plans were adjusted based on these results and the green roof installed in fall 2012. Through the first growing season the plants have responded well and are establishing as predicted. A monitoring program will track plant health and various hydrologic and ecological indicators to determine long-term success of this approach.

Besides meeting functional requirements, designs based on native plant communities enhance ecological and natural heritage value by incorporating rare or protected species. Additionally local nurseries and designers have expressed interest in the results, and the planting's long term success may lead to greater market availability and use of these species.

Keywords: green roof, native plants, alvar, dune, sustainability

* Tim Toland, 1 Forestry Drive, 331 Marshall Hall, Syracuse, NY 13210, trtoland@esf.edu

Building Integrated Vegetation

Green Roof Runoff Characterization: nutrient loading and erosion control on a newly planted green roof

Grace Harper*, Missouri S&T; Lea Ahrens, Missouri S&T; Joel Burken, Missouri S&T; Eric Showalter, Missouri S&T

Green roofs can provide energy and environmental benefits; this research targets evaluation of green roof runoff quantity, nutrient loading, and erosion prevention of two green roof systems. During a pilot study, the runoff quantity and composition from green roof material was evaluated continuously under field conditions for two different media both tested under planted and unplanted conditions. Water quantity results show over a 40% reduction in runoff from just the growing media and over 60% reduction runoff with established plants in green roof media. Previous studies have reported a "first flush" of excess nutrients but without evaluating the duration and intensity of this phenomenon throughout the first year of the roof's life. This research showed total phosphorus concentrations at 30 mg/L and nitrogen concentrations above 60 mg/L in green roof runoff initially, with concentrations decreasing over time. Media type and age were the largest influences on phosphorus and nitrogen concentrations. Understanding and modeling runoff nutrient kinetics can better aid in developing procedures to minimize nutrient runoff.

Potential wind scour of media was evaluated through wind tunnel testing at 30 mph. Because erosion can occur, surface stabilizers (i.e. adhesives) are available to secure green roof media. Green roof adhesive and plant cover both reduced wind scour down to one-tenth of observed scour without any cover. Suspended solids in the runoff was measured to evaluate the drainage layer's ability to prevent washout during storm events. The tested green roof systems were effective, with average TSS concentrations for both below 20 mg/L.

Keywords: green roof, stormwater, runoff, nutrients, erosion

* Grace Harper, 910 E Hwy N. Wentzville, MO 63385 grace.harper@mail.mst.edu

Building Integrated Vegetation

Impact of Planted Biofilters on Contaminant Loads and Ambient Humidity in Canadian Residences During the Summer 2013

David Llewellyn*, School of Environmental Sciences, University of Guelph; Alan Darlington, Nedlaw Living Walls; Michael Dixon, School of Environmental Sciences, University of Guelph

Living wall biofilters have proven effective at generating clean air under laboratory conditions as well as in commercial, industrial and institutional buildings but it is unknown how these results may translate to residential settings. While large scale living walls have been a commercial success, scale down to residential applications has numerous important design considerations. Dwellings are unique spaces in that they generally have lower ventilation rates and have less sophisticated air quality control infrastructure (eg. HVAC) used to maintain optimum conditions within the space. Consequently, residences have the potential to have substantially lower air quality than other occupied spaces. With this in mind, a new design of biofilter has been developed which may be better suited for the residential market. Design considerations are targeted at higher air flux rates, lower relative surface areas, reduced effluent humidification and improved interception of ambient light. Laboratory trials showed contaminant removal efficiencies in excess of 60% (per pass) while Clean Air Delivery Rate (CADR) was maximized and water loss minimized (per unit volume of clean air generated) at the highest air fluxes. Performance of the new design under field conditions is ongoing and results of replicated field trials will be discussed.

Keywords: biofiltration, phytoremediation, VOC, methylethylketone, trichloroethylene, toluene, indoor air

* David Llewellyn, Rm. 1212 Edmund C. Bovey Building, University of Guelph
50 Stone Rd. East, Guelph, ON, Canada, N1G 2W, dllewell@uoguelph.ca

Building Integrated Vegetation

Treatment of High Strength Organic Wastewater Using Green Walls

Scott Wolcott*, Rochester Institute of Technology and Peter Martin, Rochester Institute of Technology.

Green walls or living walls are architectural installations comprised of plants growing in soil filled, modular panels that are attached to interior or exterior walls. The objective of this study is to evaluate the possibility of using green walls to treat non-sanitary wastewater. A four foot high green wall was constructed using two, 2 ft x 2 ft panels. The panels were filled with light weight, porous, recycled glass bead media with a granular size of 4-8 mm. High strength organic wastewater (brewery wastewater) was recirculated through the system under four scenarios including media only, media with biofilm, media with plants, and media with plants and biofilm. The plants are standard pothos (Epipremnum aureum) house plants. The treatment efficiency of the scenarios was assessed by measuring biochemical oxygen demand (BOD), turbidity, and total nitrogen in treated wastewater samples collected over a 24 hour period. Significant reductions in BOD, turbidity, and total nitrogen were observed in the first six hours of treatment. Removal efficiencies of suspended solids (turbidity) and organic matter (BOD) were consistent across the four scenarios with an average 24 hour reduction of 62% and 82%, respectively. The concentration of total nitrogen was reduced by an average 27% over the 24 hour treatment period. Scenarios including biofilm growth on media resulted in greater reductions in total nitrogen. Green wall technology appears to have promise as a space and cost efficient method for treating organic wastewater generated by small to medium sized beverage and food industries.

Keywords: green walls, organic, wastewater, BOD, treatment, SME

* Scott Wolcott, 78 Lomb Memorial Drive, Rochester, New York 14623 sbwite@rit.edu

10: Inorganics I

Inorganics I

Critical issues encountered in the promotion of arsenic phytoremediation from laboratory experiments to large scale application

Mei Lei*, Tongbin Chen, Xueli Wang, Xiaoyong Zhou, Xiaoming Wan, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

The phytoremediation of arsenic (As) using hyperaccumulator *Pteris vittata* has been promoted from lab to field. Large-scale phytoremediation projects have been established in Yunnan and Guangxi province (100 hectare), China. During this process, several critical issues have been encountered, with possible solutions proposed.

For the phytoextraction of As, normally 60,000 *P. vittata* plants are needed for 1 hectare soil. The requirement of large quantity of plants, usually at short notice, is the first issue we come across. Temperature, pH and calcium content of soil have been identified as essential parameters for the efficient reproduction of *P. vittata*. We are now designing a set of nursery equipments, intelligently managing the breeding process. The second issue is the safe co-planting technology. During the phytoextraction process, normally taking several years, the owners of contaminated farmlands need economical benefits. The co-planting of hyperaccumulators and economical plants (mulberry tree and ramie) has been designed and being optimized from aspects of the distance between row and hill, planting time, harvesting time and frequency. The final issue is the treatment of harvested *P. vittata*. Arsenic immobilizing agent has been developed to ensure a pollution-free incineration process, which can decrease As concentration in flue gas from 0.17 mg m^{-3} to 1.5×10^{-3} mg m^{-3}.

There are lots of contaminated lands in China. The government plans to conduct large-scale soil remediation projects in several contaminated watersheds. Scientists are searching for feasible remediation techniques. Due to the environmental friendliness and economical efficiency, phytotechnology has become a strong candidate.

Keywords: Arsenic, field application, incineration, phytoremediation, *Pteris vittata*

* Mei Lei, No. 11(A) Datun Road, Chaoyang, Beijing 100101, China. leim@igsnrr.ac.cn

Inorganics I

Uranium uptake by hydroponically cultivated crop plants and its potential for environment decontamination

Petr Soudek IEB ASCR, Sárka Petrová IEB ASCR , Dagmar Benesová IEB ASCR, Marcela Dvoráková IEB ASCR, Tomás Vanek*, IEB ASCR

Uranium is a problematic pollutant resulting from mining, reprocessing and disposal activities related to the nuclear industry. In nature, uranium can be found in the Earth's crust at an average concentration of about 2.5 mg/kg but anthropogenic activities, such as utilization of depleted uranium in munitions and nuclear accidents, introduce uranium to the environment on a larger scale. The monitoring of the movement of uranium from soil to plants, especially to edible plant parts, is very important due to possible contamination of the food chain. Uranium presents an exposure hazard due to its chemical toxicity as well as the radioactivity resulting from its decay and its decay products.Bioavailability is one of the limiting factors for uranium uptake by plants. Twenty different plant species were tested in hydroponic solution supplemented by 0.1 mM or 0.5 mM uranium concentration. The uranium accumulation of these plants varied from 0.16 mg/g DW to 0.011 mg/g DW. The highest uranium uptake was determined for Zea mays and the lowest for *Arabidopsis thaliana*. The amount of accumulated uranium was strongly influenced by uranium concentration in the cultivation medium. Autoradiography showed that uranium is mainly localized in the root system of the plants tested. Additional experiments demonstrated the possibility of influencing the uranium uptake from the cultivation medium by amendments. Tartaric acid was able to increase uranium uptake by *Brassica oleracea* and *Sinapis alba* up to 2.8 times or 1.9 times, respectively. Phosphate deficiency increased uranium uptake up to 4.5 times or 3.9 times, respectively, by *Brassica oleracea* and *S. alba*.
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Keywords: uranium, *Brassica, Sinapis*

* Tomás Vanek, Laboratory of Plant Biotechnologies, Institute of Experimental Botany AS CR, v.v.i. Rozvojová 263, 165 02 – Prague 6, Czech Republic, vanek@ueb.cas.cz

Inorganics I

Identification of the Genes Expressed in Willows during Phytoremediation

Frederic E. Pitre*, Emmanuel Gonzalez, IRBV, Julie Marleau, IRBV, Michel Labrecque, IRBV, Vanessa Grenier, IRBV, Hafssa Kadri, IRBV, Werther Guidi, IRBV, Simon Joly, IRBV

The GenoRem project develops innovative phytoremediation procedures for polluted soils, deploying the decontamination potential of willows associated with fungal and bacterial symbionts. A greenhouse trial was established with our model willow cultivar, *Salix purpurea* ‘Fish Creek’. The experiment consisted of six treatments (including a control without a plant), testing the effect of contaminants in soil (excavated from a contaminated field trial), and of mycorrizal (*Glomus irregulare*) pre-inoculation.

Information on plant physiology and organic soil pollutants was collected and a *de novo* transcriptome of leaves, stems and buds of *Salix purpurea* ‘Fish Creek’ growing in contaminated soil was assembled. The quality of the transcriptome data is good and shows the presence of tissue-specific and ubiquitous genes. Differential expression analyses showed a clear cross-tissue contamination effect, with several genes significantly differentially expressed highlighting potential genes and pathways involved in phytoremediation. For instance, transcripts involved in the detoxification and transport of organic compounds (cytochrome P450, Transparent Testa 12 were significantly over-expressed in the plant tissues obtained from the contaminated environment.

Finally, another experiment will compare the transcriptomic response induced in 8 willow cultivars planted in a field trial. Leaves, stems, and roots were harvested and will be used to perform an in depth eco-transcriptomics comparisons of the sequences induced in a real life phytoremediation context.

Keywords: Phytoremediation, *Salix*, Transcriptomics, RNA Sequencing,

* Frederic E. Pitre, IRBV, 4101 Sherbrooke East, Montreal, Québec, Canada, frederic.pitre@umontreal.ca

Inorganics I

Role of HMA2 in accumulation of cadmium in two near isogenic lines of wheat

Michael Tavarez*, Lehman College, Renuka Sankaran, Lehman College, City University of New York

Cadmium (Cd) is one of the most toxic heavy metals and has shown to have detrimental effects on soil biological activity, plant metabolism, and human health. In the U.S., Cd concentration for topsoil in major agricultural production areas range from <0.01 to 2.0ppm, while the worldwide average Cd concentration in surface soils is 0.53ppm. Due to similarities it's similarities to the essential micronutrient Zinc (Zn), the nonessential heavy metal Cd is often taken up and accumulated in seeds of commercially grown cereals like wheat *(Triticum turgidum)*. In fact, dietary Cd is the leading cause of Cd exposure to non-smokers. In order to limit the Cd that is deposited into grains, we must first understand the mechanism of uptake and translocation in wheat. The main hypothesis of this study is that xylem loading process can restrict root to shoot translocation of Cd and hence affect the grain Cd concentration. The specific objective of the proposed study is to assess the contribution of the xylem loading transporters in the mobilization of Cd and Zn to the seeds in two wheat isolines differing in grain Cd concentration. Members of P_{1B}ATPases (HMA), HMA2 and HMA4 have been shown to be the principal transporters contributing to xylem loading of Cd in Arabidopsis. Studying the expression difference in HMA2 and HMA4 will help us decide if there is a difference in xylem loading process between the two lines contributing to the difference in grain Cd accumulation. The findings from the study will be presented.

Keywords: cadmium, zinc, wheat, transport, accumulation

* Michael Tavarez, 250 Bedford Park Blvd West, Bronx, NY 10468. iammichael88@yahoo.com

Inorganics I

Phytoremediation of lead (Pb) contaminated soils by Transgenic *Helianthus annuus L.*

Vasavi Adipudi, Department of Biotechnology, Sri Padmavathi Mahila Visvavidyalam*; Usha R, Department of Biotechnology, Sri Padmavathi Mahila Visvavidyalam, Tirupati, India

Genetic engineering of plants for phytoremediation is thought to be possible based on results using model plants expressing genes involved in heavy metal resistance, which improve the plant's tolerance of heavy metals and accumulation capacity. The next step of progress in this technology requires the genetic engineering of plants that produce large amounts of biomass and the testing of these transgenic plants in contaminated soils. Thus, we transformed YCF1 (yeast cadmium factor 1), which encodes a transporter that sequesters toxic metals into the vacuoles. The YCF1-expressing transgenic *Helianthus annuus L.* plants exhibited enhanced growth, reduced toxicity symptoms, and increased Pb content in the aerial tissue compared to the non-transgenic plants. These results suggest that the generation of YCF1-expressing transgenic *Helianthus annuus L.* represents the first step towards producing plants for phytoremediation.

Keywords: phytoremediation, YCF 1, transgenic plants, Helianthus annuus L.

* Vasavi Adipudi, Department of Biotechnology, Sri Padmavathi Mahila Visvavidyalayam, Tirupati, India. vasavi.a307@gmail.com

Influence of arsenic and phosphorus competitive uptake on arsenic tolerance in bacteria and arsenic-hyperaccumulator *Pteris vittata* L.

Piyasa Ghosh*, Soil and Water Science Department, University of Florida, Lena Q. Ma, Soil and Water Science Department, University of Florida and Bala Rathinasabapathi, Horticultural Sciences Department, University of Florida

Arsenic contamination of soil and water has created serious health concern all over the world. Arsenic hyperaccumulator *Pteris vittata* L. (Chinese Brake fern) is capable of extracting arsenic from both soluble and insoluble forms, due to composite action of the plant roots and rhizosphere microorganisms. Seven As-resistant bacteria (ARB; tolerant up to 10 mM AsV) from 3 genera were isolated from the rhizosphere soils.

The siderophores produced from rhizobacteria solubilized arsenic from $FeAsO_4$/$AlAsO_4$ minerals, increasing arsenic uptake by *P. vittata* from 18.1–21.9 to 35.3–236 mg kg^{-1} arsenic in the fronds. The root biomass of *P. vittata* increased from 1.5-2.2 to 3.4-4.2 g dw/plant when amended with the bacteria in the growth medium due to arsenic-induced P uptake. As AsV and P are chemical analogs they affect the uptake of each other. We tested the influence of different AsV concentrations of 0.1 and 1 mM AsV compared to no arsenic control on P uptake, utilization and AsV reduction rates and vice versa. Bacteria take up 3-8.4 times more P in presence of 1 mM AsV than in no AsV condition due to arsenic-induced P uptake. In bacteria we have also found that higher P concentration in the bacterial medium can lower the uptake of AsV resulting in less AsV reduction to AsIII. So, in presence of P plants and bacteria may be more tolerant to arsenic. In contaminated sites arsenic-resistant rhizosphere bacteria can aid plant growth and enhance phytoextraction of arsenic-contaminated soil.

Keywords: arsenic, arsenic-resistant bacteria, rhizosphere, *Pteris vittata,* plant-microbe interaction

* Piyasa Ghosh, 2169 McCarty Hall A, Gainesville, Fl piyasaghosh@ufl.edu.

11: Long Term Results and Restoration

Phytoremediation of petroleum and salt-impacted soils: Successfully meeting generic Tier 1 standards and making green technologies work

Greg MacNeill*, University of Waterloo, Scott Liddycoat, University of Waterloo, Xiao Ming Yu, University of Waterloo, Xiao-Dong Huang, University of Waterloo, Peter Mosley, Waterloo Environmental Biotechnology, Perry Gerwing, Earthmaster Environmental Strategies Inc, Bruce M. Greenberg, University of Waterloo

We have successfully developed advanced phytoremediation systems for removal of petroleum hydrocarbons (PHCs), PAHs and salt from soils. The plant growth promoting rhizobacteria (PGPR) enhanced phytoremediation systems (PEPS), when implemented by properly trained personnel, increases root biomass in impacted soils and promotes growth of rhizosphere microorganisms. The rhizosphere biomass facilitates rapid partitioning of contaminants out of the soil, and their subsequent uptake and metabolism by microbes and plants. The result is PHC and salt remediation to Tier 1 standards. From 2007 to 2012 we implemented PEPS at for PHC remediation 19 sites in almost every Canadian province and achieved ~35% remediation/year. We have met Tier 1 standards at 8 sites, and anticipate achieving remediation goals within a 2 to 3 year treatment period at the remaining 11 sites. Our work shows that PEPS is effective at a wide variety of PHC-impacted sites, with a complete remediation time frame of 2 to 3 years. We are now refining CCME PHC analytical methods to make phytoremediation more efficient. In 2009, we initiated full-scale PEPS deployment at 10 salt-impacted sites in Saskatchewan, Alberta and the Northwest Territories. PGPR greatly enhanced plant growth on the salt-impacted soils, allowing good plant growth on soils with EC_e's up to 25 dS/cm. Furthermore, the plant salt up-take is sufficient to make phytoremediation feasible; we have already achieved salt remediation to regulatory targets at 3 sites. The advanced PEPS technologies described above are based on procedures that have been scientifically proven and are effective at full-field scales.

Keywords: soil, phytoremediation, petroleum, salt, field scale

* Greg MacNeill, 200 University Ave W, Waterloo, ON, Canada gmacneil@uwaterloo.ca

Long Term Results and Restoration

Long-term Effects of Phytoremediation on Diesel and Crude Oil Contaminated Soils in Cold Regions

Mary-Catherine Lewis, University of Alaska Fairbanks, Charles M. Reynolds, US Army Cold Regions Research and Engineering Laboratory; and Mary Beth Leigh*, University of Alaska Fairbanks

Remediating contaminated soils in cold remote regions is difficult. Depending on the contaminant, phytoremediation mechanisms can include plant uptake, degradation within the plant, volatilization through the plant, enhanced degradation in the rhizosphere, and specific enrichment due to chemical analogs released as exudates; we focused primarily on the latter two. Although mechanisms for phytoremediation are still being investigated, there is convincing evidence for its efficacy. The Army Corps of Engineers Cold Regions Research and Engineering Laboratory established a phytoremediation experimental site in Fairbanks in 1995 to determine how the addition of plants (annual ryegrass (*Lolium multiflorum*) or annual ryegrass-arctared fescue (*Festuca rubra*) mix), nutrients, or their combination would affect degradation of petroleum hydrocarbons (PHC) contaminated soils over time. After the initial set of studies was completed, the site was left without additional treatment or maintenance, during which time volunteer plants colonized the plots. A subsequent study is investigating the long-term changes in petroleum concentrations, microbial function, and plant colonization. We characterized the resulting plant species for the different treatments using composition and percent cover. Preliminary analyses indicate a relationship between the trajectory of native plant succession and the planting and fertilization treatments originally applied 16 years ago. The microbial communities are being investigated to quantify and identify microorganisms and functional genes associated with petroleum degradation, and to examine the relationship between petroleum-degrading microbes and plant vegetation type. This long-term study will provide insight into the mechanisms, efficacy, and plant succession for phytoremediation of petroleum contaminated soils in cold regions. .

Keywords: PAH phytoremediation

* Mary Beth Leigh, Institute of Arctic Biology, Fairbanks, Alaska, U.S.

Long Term Results and Restoration

Nitrate Remediation of Soil and Groundwater Using Phytoremediation

Sheldon Nelson*, Chevron Energy Technology Company

The basic concept of using a plant-based remedial approach (phytoremediation) for nitrogen containing compounds is the incorporation and transformation of the inorganic nitrogen from the soil and/or groundwater (nitrate, ammonium) into plant biomass, thereby removing the constituent from the subsurface. There is a general preference in many plants for the ammonium nitrogen form during the early growth stage, with the uptake and accumulation of nitrate often increasing as the plant matures. The synthesis process refers to the variety of biochemical mechanisms that use ammonium or nitrate compounds to primarily form plant proteins, and to a lesser extent other nitrogen containing organic compounds.

The shallow soil at the former warehouse facility test site is impacted primarily by elevated concentrations of nitrate, with a minimal presence of ammonium. Dissolved nitrate (NO_3^-) is the primary dissolved nitrogen compound in on-site groundwater, historically reaching concentrations of 1000 mg/L.

The initial phases of the project consisted of the installation of approximately 1750 trees, planted in 10-foot centers in the areas impacted by nitrate and ammonia in the shallow soil and groundwater.

As of the most recent groundwater analytical data, dissolved nitrate reductions of 40% to 96% have been observed in monitor wells located both within, and immediately downgradient of the planted area.

In summary, a comparison of groundwater analytical data from the initial planted grove to that collected from upgradient and crossgradient wells suggests that the trees are an effective means of removing dissolved nitrate from underlying groundwater. The mechanism of concentration reduction may be the uptake of residual nitrate from the vadose zone, the direct uptake of dissolved constituent from the upper portion of the saturated zone/capillary fringe, or a combination of these two processes.

Keywords: nitrates, groundwater, long term results

* Sheldon Nelson, 6001 Bollinger Canyon Road, San Ramon, California 94583
snne@chevron.com

Valuation of Phytotechnology Benefits: More than Just 'Aesthetically Pleasing'

Joel G. Burken*, Missouri S&T; Ronald Zalesny, Northern Research Station, US Forest Service; Kate Kennan, Offshoots, Inc.,

In many instances we discuss the treatment potential of phytotechnologies, and add in 'publically accepted and aesthetically pleasing' as ancillary benefits. In the selection process of a remedial technology, these ancillary benefits are difficult to value and have rarely have approaches been coordinated to provide not just a cost benefit assessment related to project finance (cost) and treatment efficacy (benefit) but also value the non-treatment related benefits of plant-based approaches. Rather valuation of phytotechnologies can be made considering the true economic valuation. Economics is not just project finance, but is the"allocation of scarce resources." These scarce resources can include valuation of phytotechnologies benefits far more than just treatment. As a society we greatly value energy and phytotechnologies are not only energy efficient and conserving, but also can generate energy resources in biomass resources. We also greatly value beautification of our surroundings, recreational and 'green spaces' in urban settings.

Case studies and methods of assessing value will be presented in this talk to some to an economic benefit for phytoremediation of: Value = Treatment efficacy + ecosystem benefit + aesthetic value + possible energy resources (biomass) + recreation + energy conservation.

The valuation of phytotechnologies is far more than just treatment and in many cases the 'ancillary benefits' can provide greater economic value than the treatment, and contribute greatly to the overall treatment decision process.

Keywords: Aesthetic benefit, ecosystems services, phytotreatment, biomass

* Joel G. Burken, 1401 N. Pine St, Rolla, MO 65409 burken@mst.edu / kate@offshootsinc.com

Phytoremediation of irrigation water with *Limnocharis flava, Thalia geniculata* and *Typha latifolia* in constructed wetlands

Percy Erasmus Korsah*, Coventry University, Alexander K. Anning, Ohio University, Patrick Addo-Fordjour, University of Kuala lumpur.

Phytoremediation is generally believed to be an efficient, cost-effective and sustainable wastewater treatment option for developing countries, although the technology has yet to be fully explored in these countries. The purpose of this study was to assess the potential of three aquatic plants, *Limnocharis flava*, *Thalia geniculata* and *Typha latifolia*, as phytoremediants of heavy metal contaminated irrigation water in Kumasi (Ghana) using a constructed wetland. The wetland consisted of three treatment lines each planted to one of the species. Duplicate plant and water samples were collected bi-monthly and analyzed for Fe, Cu, Zn, Pb and Hg using the AAS over a six month period. The results showed substantial accumulation of the trace metals by the plants, with Fe (~1600mg kg^{-1}) and Pb (5.71mg kg^{-1}) respectively as the most and least accumulative metals. Bioaccumulation and translocation factors varied greatly among species for different metals. *L. flava* and *T. geniculata* hyperaccumulated Hg. Removal efficiencies ranged from a mean of ~20% for Cu and Pb to ~70% for Fe, but did not differ statistically ($P >$ 0.05) among species. Our study suggests that phytoremediation with *L. flava, T. geniculata* and *T. latifolia* has potential for purification of irrigation water.

Keywords: bioaccumulation, heavy metal, Kumasi, removal efficiency, translocation

* Percy Erasmus Korsah, 43 Monks road, Coventry, CV1 2BZ, UK percykorsah@yahoo.com

Long Term Results and Restoration

White Island: From Trash to Treasure

Karah Conklin*, Roux Associates, Inc. and Amanda Ludlow, Roux Associates, Inc.

White Island, an 80-acre former municipal landfill located in Brooklyn, New York, is one of the first grassland mitigation projects required by New York State. The former landfill exhibited severe erosion and was dominated by invasive species. Restoration of the island to high quality maritime grasslands was completed by the City of New York Department of Parks & Recreation in spring 2013. The project served as mitigation for the loss of 56 acres of maritime grassland habitat due to construction of a nearby Housing Development and Retail Center. The NYSDEC determined the loss of grassland habitat was a significant adverse impact on several bird species and the creation of new maritime grassland habitat on White Island was required as compensatory mitigation. The main objectives of the restoration design were to:

- Create habitat for rare or special-status species;
- Increase biodiversity;
- Control invasive species; and
- Improve shoreline stability.

The design incorporated several vegetative zones to provide suitable diverse habitat for ground nesting avian species, while supporting habitat for other wildlife. The vegetative zones were designed to provide contiguous acres of suitable grasslands habitat, maximize edge diversity, provide shelter and control erosion. Over 150,000 cubic yards of sand was installed across the island surface to create a planting substrate free of invasive species for the colonization by a variety warm-season grasses to attract ground nesting shorebirds. Additionally, various vegetative bioengineering stabilization practices were implemented along the island's shoreline to contain landfill waste and provide a connective vegetated zone along the shore for wildlife use.

Keywords: Ecorestoration, habitat creation, shoreline stabilization, grassland mitigation

* Karah Conklin, 209 Shafter Street, Islandia, NY kconklin@rouxinc.com

12: PAH Petroleum Remediation

PAH Petroleum Remediation

PAH Removal in Soils at a Phytoremediation Site in North Carolina

Andrew McEachran*, North Carolina State University; Joshua Kotheimer, North Carolina State University; and Elizabeth Guthrie, North Carolina State University

We report on changes in concentrations of 29 to 42 polycyclic aromatic hydrocarbons (PAHs) in soils at a 5-acre, mixed tree phytoremediation demonstration site that was planted in 2007 in Elizabeth City, NC after 5 years of tree growth. The goal of this project is to use trees to decrease groundwater recharge, flow, and mixed-fuel contaminant concentrations in a shallow, water-table aquifer that discharges to the Pasquotank River. The site was planted with 3,000 trees in 2007 and consists primarily of hybrid poplars (*Populus spp*.; 94%); willow (*Salix sp*.; 5%); and loblolly pine (*Pinus taeda;* 1%). Soil gas analyses show significant reduction of total petroleum hydrocarbons (TPH) mass at the site from February 2007 to December 2012; groundwater concentrations of BTEX and MTBE are significantly lower than historical data prior to tree installation work. Fuel product thickness has also declined over time. PAH concentrations in soils collected from the same locations in 2008, 2010, and 2012 also show significant declines from 2008 to 2012. Biological degradation is considered the primary means for PAH removal and is supported by enhanced weathering indices of key PAH analytes over time.

Keywords: Petroleum remediation

* Andrew McEachran, North Carolina State University, Department of Forestry and Environmental Resources, College of Natural Resources, 3120 Jordan Hall Raleigh, NC 27695-8008 elizabeth_nichols@ncsu.edu

PAH Petroleum Remediation

Polycyclic aromatic hydrocarbons fate in urban area: Case studies in Poland and Norway

Stanislaw Gawronski*, WULS, Arne Sæbo, Bioforsk, Kajetan Dzierzanowski, WULS, Juliusz Markowski, WULS, Helena Gawronska WULS

PAHs are one of the most common pollutants in urban area, mainly of anthropogenic origin (fuel-burning, motor vehicle, asphalt production, shall gas exploration). PAHs, with some being carcinogenic and mutagenic, receive recently more attention in risk assessment of air pollution to man. Ability of 4 woody species and 2 grass to accumulate 16 PAHs were determined in Poland and Norway. Plants where cultivated in polluted (city downtown) and clean sites (nursery garden). Significant differences were found in PAHs level between counries, sites (being always higher in Poland and polluted location) as well as between tested species. PAHs removed from air by rain directly and washed off leaves are deposited in the soil. Their degradation in soil can be stimulated by vegetation and/or selected microorganisms Some grasses are known from stimulation of multiplication of microorganisms that are capable to degrade ring structure compounds Two grass species (recommended for road side cultivation) with addition of spent mushroom substrate after *Pleurotus ostreatus* cultivation, *Trichoderma harzianum* T-22 and EM (Effective Microorganisms) consortium were used for evaluation of the effectiveness of PAHs degradation. Studies are in progress and results will be presented.

Keywords: bioremediation, PAHs, *Pleurotus ostreatus, Trichoderma harzianum*, EM-microorganisms

* Stanislaw Gawronski, Warsaw University of Life Science, str. Nowoursynowska 159, 02-787 Warsaw, Poland stanislaw_gawronski@sggw.pl

Diesel Oil Degradation Triggered By Plant Growth Promoting Bacteria Isolated From Poplar Trees Growing On A Diesel Contaminated Plume

Panogiotis Gkorezis, Hasselt University, Belgium; Jonathan Van Hamme, Thompson Rivers University, Canada; Andrea Franzetti, University of Milano-Bicocca, Italy; Matteo Dagghio, University of Milano-Bicocca, Italy; Wouter Sillen, Hasselt University, Belgium; Nele Weyens, Hasselt University, Belgium; Jaco Vangronsveld*

Diesel fuel is a complex hydrocarbon mixture, characterized by high toxicity and carcinogenic potential. This study was performed to unravel the potential role of plant – bacteria partnerships in bioremediation processes, aiming to develop a robust system for the remediation of soils and groundwater contaminated with petroleum hydrocarbons as well as BTEX. For that reason, hybrid poplars [*Populus deltoides* x (*trichocarpa x deltoides*) cv Grimminge] were planted to contain and remediate a diesel plume at a contaminated industrial site in Belgium. Plant roots and soil were sampled in order to isolate bacteria able to grow in the presence of, and to biodegrade, diesel fuel. The isolated bacteria were genotypically characterized based on the 16S rDNA gene and the analysis revealed 20 different taxa, with *Pseudomonas* and *Acinetobacter* as the most abundant genera. All the isolated cultivable bacteria were tested for their capacity to produce various plant growth promoting traits. The 2,6 DCPIP assay and GC-MS analysis were used for a more in depth examination of the diesel degradation rate and revealed that 25 of 380 isolates, were able to degrade diesel. The two strains with the highest degradation rates were selected for a draft genome sequencing using the Ion Torrent technique. Data from a greenhouse study along with bioinformatics analysis are used to unravel whether the corresponding strains can be exploited for increased remediation efficiency of petroleum hydrocarbon contaminated environments.

Keywords: diesel, degradation, phytoremediation, plant-associated bacteria

* Jaco Vangronsveld, Hasselt University, Centre for Environmental Sciences, Agoralaan, building D, B-3590 Diepenbeek, Belgium. jaco.vangronsveld@uhasselt.be

PAH Petroleum Remediation

Leucanthemum vulgare flavonoid content during crude oil phytoremediation

Azamsadat Noori*, Department of Plant sciences, College of Biological Science, TMU; Hassan Zare Maivan, Department of Plant sciences, College of Biological Science, TMU; Ebrahim Alaie, Research Institute of Petroleum Industry (RIPI)

Leucanthemum vulgare, formerly known as *Chrysanthemum leucanthemum*, is an ornamental plant which can grow in different climates in North America, Europe and Asia. It has historically been used as medicinal herb to remedy various ailments such as asthma, nervous afflictions, jaundice, menstrual problems, and fevers. *L. vulgare* contains many different flavonoid compounds such as Apigenin, Quercetin and Morin. In current research, changes in the contents of Apigenin, Quercetin and Morin in roots, leaves, and flowers of the *L. vulgare* were investigated in plants grown in the presence of 2.5, 5, 7.5, and 10% crude oil in soil over a period of six months in greenhouse under ambient conditions. Concentrations of the selected flavonoids were determined using a HPLC method. Soil TPH was measured to determine *L. vulgare* potential ability in crude oil phytoremediation. Results showed that soil TPH decreased significantly (55%) in the presence of *L. vulgare* compared to control and blank. The flavonoids contents changed significantly ($p \leq 0.05$). Concentrations of Apigenin increased from 70 to 95% in root and leaf tissues over increasing crude oil treatments, Morin and Quercetin contents in roots increased from 85 to 91% and from 80 to 94% respectively. This research showed that *L. vulgare* can be used as an ornamental plant on crude oil contaminated sites to remediate soil while providing medicinal benefits through improved production of Apigenin, Quercetin and Morin.

Keywords: Abiotic stress, Crude oil, Flavonoids, *Leucanthemum vulgare,* phytoremediation

* Azamsadat Noori, 416 Illick Hall, 1 Forestry Drive, Syracuse, NY, 13210
g-antooran@esf.edu

Phytoremediation to Degrade Total Petroleum Hydrocarbons (TPH) using Mixtures of Grass and Willow Species

Patrick McIntosh*, University of Connecticut Department of Plant Science and Landscape Architecture (UCPSLA); Julia Kuzovkina UCPSLA, Cristian P. Schulthess UCPSLA, Karl Guillard UCPSLA,

Total Petroleum Hydrocarbons (TPH) is a class of recalcitrant organic pollutants that can harm human health through exposure to carcinogenic and mutagenic constituents. Phytoremediation can help sequester, volatilize, or degrade TPH in contaminated soil. An *ex-situ* analysis was conducted to determine the potential for phytoremediation of TPH in contaminated soil from a railroad yard. Soil was collected from a designated area at the rail yard then dried and sieved through a 6.35-mm screen. The soil was then homogenized and placed into pots planted with grasses [perennial ryegrass (*Lolium perenne*), sheep fescue (*Festuca ovina*), tall fescue (*F. arundinacea*), switchgrass (*Panicum virgatum*)] or willows [SV1 (*Salix dasyclados*), S25 (*S. eriocephala*), SX67 (*S. miyabeana*), S99113-012 (*S. purpurea*)], either alone or in combination. Amendments included addition of N, P, and K fertilizer with and without molasses to soil in planted and unplanted pots. Unplanted soil without amendments served as a control. Degradation of TPH was measured by using gas chromatography, and indigenous bacteria were quantified by colony-forming units grown in beef-extract nutrient agar plates. Preliminary data show increases in plant biomass with amendments. Microbial communities in soil with plants and amendments were enhanced by orders of magnitude compared to unplanted control. Initial homogenization of soil had significant loss of TPH before planting. Chromatograms of soil with plants and amendments decreased TPH more than soil without plants or amendments. These initial results suggest that adding soil amendments with the addition of plant species have the potential of enhancing phytoremediation of TPH.

Keywords: phytoremediation, petroleum hydrocarbons, salix, poaceae, gas chromatography

* Patrick McIntosh, 1390 Storrs Rd., Storrs, CT patrick.mcintosh@uconn.edu

13: Inorganics II

Inorganics II

Selenium phytoremdiation – bioremediation system: A long term sustainable approach to manage threatened agricultural areas

John Freeman*, CSU Fresno / NASA-Ames; Gary Banuelos, USDA-ARS; Krassimira Hristova; Marquette, Radomir Schmidt, UC Davis

Our integrated on-farm drainage management system (IFDM) uses salt tolerant crops, selenium hyperaccumulator plants, and halophytic plants to manage excess salt /selenium in agricultural drainage impacted soils / irrigation drainage water. The phytoremediation of selenate laden soils is especially efficient using the Selenium hyperaccumulator *Stanleya pinnata.* On a larger field scale we achieved the hyperaccumulation and removal of substantial Se in the above ground shoots of high biomass producing salt and boron tolerant *S.pinnata* hybrids*.* Furthermore, the excess Se in runoff waters from the IFDM is directed into an integrated engineered aquatic ecosystem specifically designed to bioremediate selenate. This engineered aquatic ecosystem also produces brine shrimp enriched in organic-Se, omega-3 and omega-6 fatty acids for use in value added nutraceutical food supplements. By analyzing the internal Se concentrations of the various food web organisms present in the engineered aquatic ecosystem we show that selenate was successfully bioremediated by micro-algal metabolism into organic-Se (seleno-amino acids and gaseous volatile-Se). Selenium is also removed by using nets to harvest the brine shrimp that had accumulated substantial amounts of organic-Se after eating aquatic microorganisms. Thriving in this pond system, brine shrimp (*Artemia franciscana* Kellogg) and brine fly (*Ephydridae* sp.), also have ecological relevance as important food sources for large populations of waterfowl, breeding and migratory shore birds. Together with the salt and boron tolerant crops, selenium hyperaccumulator plants, and halophytes this phytoremediation – bioremediation IFDM system represents a long term sustainable approach to manage and potentially rehabilitate currently threatened agricultural areas.

Keywords: Selenium hyperaccumulator-plants, engineered aquatic-ecosystem, IFDM

* John Freeman, NASA-Ames Research Center, Moffett Field, Mountain View CA
john.l.freeman@nasa.gov

Inorganics II

Repeated phytoextraction of four metal contaminated soils by *Sedum plumbizincicola*, a Cd/Zn hyperaccumulator

Zhu Li, Longhua Wu*, Key Laboratory of Soil Environment and Pollution Remediation, Institute of Soil Science, Chinese Academy of Sciences

To understand soil heavy metal phytoextraction process, a Cd/Zn hyperaccumulator *Sedum plumbizincicola* was used to extract metal from four contaminated soils for seven crops during three years. Cd/Zn uptake by plant, *aqua-regia*, 0.01 M $CaCl_2$, 1M NH_4OAc, and diffusive gradients thin-films (DGT) extractable metal fractions were measured to investigate the dynamics plant metal uptake and soil metal concentrations during repeated phyto-extraction. The results showed that *Sedum plumbizincicola* the "average metal day-uptake"[#] in plant shoot of each crop decreased with the increase of remediation times for high metal level in acid soils, but kept "constant" for Cd in low polluted level of acid soil, and for Cd/Zn in alkaline soils, for the later phenomenon could be related with no big change of metal desorption rate from soil solid fractions in the phytoextraction process; after phytoextraction both total and available metal had great decreased, the decreases of acid soils were larger than alkaline soils, and the decrease of available fraction larger than total; R value based on DGT and K_d (the ratio between metal in soil solution and extracted by 0.01 $CaCl_2$) suggesting the ability of metal resupply from solid fraction when metal in soil solution depletion was weak and had no obvious change in acidic clay soil (pH 4.32) after the phytoextraction, increased in acidic silt soil (pH 5.68), and the resupply was good in two alkaline soils but decreased after phytoextraction, which may indicate the final state of phytoextraction is low metal in soil solution and low resupply.

Keywords: remediation, metal availability, resupply, DGT

*Wu Longhua, 71 East Beijing Road, Nanjing 210008, PR China, lhwu@issas.ac.cn

The "average metal day-uptake" in shoot was calculated by the biomass multiplies the concentration then divided by the growth time (d) in each crop.

Inorganics II

Miscanthus x giganteus for phytoremediation of contaminated soils

Valentina Pidlisnyuk*, Kremenchuk National University/ Matej Bel University; Larry Erickson, Kansas State University; Iveta Nagyova and Zuzana Melichova, Matej Bel University

Ukraine and Slovakia have an intensive agriculture and developed metal mining industry. Metal contaminated sites are widely spread causing negative impact to the environment and human health.

By union of phytoremediation and production of biofuel crops the problem can be resolved. *Miscanthus x giganteus,* second generation biofuels crop, looks promising in terms of good harvest yield, even at sites with contaminated soils.

Some laboratory research testing *Miscanthus x giganteus* for phytoremediation of soil contaminated by Co or Cu was done. The results showed that crop is relatively effective for uptake of Cu and less effective for Co. The highest concentration of Cu was detected in the roots and smaller concentrations were in staves and leaves. Co was detected only for highest treated concentration of metal and only in the roots.

The use of Miscanthus *x giganteus* for phytoremediation of soil contaminated by heavy metals depends mainly on the nature of contaminated metals, less dependence was found for the time of phytoremediation process. *Miscanthus x giganteus* biomass harvested at Co contaminated soil may be used for energy production because the above surface part accumulated only limited traces of the metal.

Keywords: phytoremediation; *Miscanthus x giganteus;* biomass, heavy metals

* Valentina Pidlisnyuk, 20 Pershotravneva, Kremenchuk, 39614, Ukraine/ 40 Tajovskeho, Banska Bystrica, 97401, Slovakia pidlisnyuk@gmail.com

Inorganics II

A Long-term Study to Evaluate the Phytoremediation Potential of *Pteris vittata* L. and *Pityrogramma calomelanos* var. *austroamericana*

Nabeel Khan Niazi*, University of Sydney; Balwant Singh, University of Sydney; Lukas Van Zwieten, Wollongbar Primary Industries Institute; Anthony George Kachenko, Nursery & Garden Industry Australia

This study evaluated the phytoextraction potential of the two arsenic (As) hyperaccumulating fern species, *Pityrogramma calomelanos* var. *austroamericana* (gold dust fern) and *Pteris vittata* (Chinese brake fern) over 27-month duration at an As-contaminated cattle-dip site at Wollongbar, NSW, Australia.

The ferns planted in January 2009 were harvested following 10, 22 and 27 months of growth. Total As concentration was determined in soil samples taken at 0−20, 20−40, and 40−60 cm depths; a detailed sampling was performed at planting stage and limited number of samples were taken at post-experiment stage. After 27-month of growth, gold dust fern removed 2.65 times higher As (25.4 kg As ha^{-1} in Plot B) than Chinese brake fern (9.7 kg As ha^{-1} in Plot A). The cumulative frond As uptake data revealed that gold dust fern extracted 1.7−3.9% and Chinese brake fern removed 0.53−1.5% of total As from soil. However, for the surface and subsurface layers, the (post-experiment) soil As data indicated that total As concentration in soil was reduced by 49% and 63%, respectively, using gold dust fern; and 17% and 15%, respectively, by Chinese brake fern. It is recommended that frond As uptake should be considered to evaluate the phytoremediation efficiency of the two fern species at the experimental site.

We estimate that with gold dust fern it would take 55−125 years to decrease mean total As content below EIL value of 20 mg kg^{-1} in Australia, whereas with Chinese brake fern 143−412 years would be required to achieve this target.

Keywords: Phytoextraction; geostatistical model; cattle dip sites, spatial variability, *Pityrogramma calomelanos* var. *austroamericana*; *Pteris vittata*

* Nabeel Khan Niazi, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Punjab – 38040, Pakistan; Email: nabeel.niazi@uaf.edu.pk

Estimation of the applicability of phytoremediation to As contaminated soil by tsunami sediments with native-grown fern in north-east region of Japan

Kazuki Sugawara*, Graduate School of Environmental Studies, Tohoku university; Akihiro Kobayashi, Graduate School of Environmental Studies, Tohoku university; Masayoshi Hatayama, Graduate School of Environmental Studies, Tohoku university; Chihiro Inoue, Graduate School of Environmental Studies, Tohoku university

The tsunami on March 11, 2011 has caused wide-reaching damage to coastal area in north-east region of Japan including the problem of soil contamination by tsunami sediments. It was reported arsenic(As) has exceeded the Japanese allowable limits of water extraction (10 mg/L) in the area. Thus, it is required that to clean up As pollution from extensive region. In the present study, we estimated the applicability of phytoremediation in north-east area of Japan by cultural test using tsunami sediments under natural condition with three kinds of fern which have ability to accumulate arsenic: *Pteris vittata*, a tropical plant; *Pteris cretica;* and *Pteris multifida,* grow naturally in temperate to subarctic climate. The biomass of shoots was close to the same in three different ferns. However the biomass of roots, *P.multifida* was 2.5 to 3-fold higher than the other ferns. On the other hand, Arsenic concentration of *P. vittata* and *P. cretica* absorbed about 186 and 174 ppm in shoot. In contrast, *P. multifida* accumulated less than half of the concentration of arsenic accumulated by other ferns. In the soil analysis, chemical form of arsenic had changed, especially oxide-form As was increased by weathering. Total As in soil decreased in the case of *P.vittata* and *P. cretica* were planted significantly. In conclusion, three different ferns could survive in the tsunami sediments mixiture and accumulate high concentration of arsenic. Particularly *P. cretica*, which grow naturally in north-east region of Japan, showed ability to accumulate arsenic comparable to arsenic hyperaccumulator *P.vittata*.

Keywords: arsenic, tsunami sediments, phytoremediation, *Pteris vittata, Pteris cretica*

* Kazuki Sugawara, 6-6-20, Aramaki-Aoba, Aobaku, Sendai, Miyagi, 980-0849, Japan
sugawara@er.kankyo.tohoku.ac.jp

14: Carbon Sequestration

Carbon Sequestration

Oxysterols Increase CO_2 Fixation by RuBisCO and the Activity of the Oxygen Evolving Complex

Marek Kamlar, Institute of Chemical Technology in Prague; Olga Rothova, Charles University in Prague ; Ondrej Uhlik, Institute of Chemical Technology in Prague ; Dana Hola, Charles University in Prague; Jan Rezek, Institute of Chemical Technology in Prague; Marie Kocova, Charles University in Prague ; Juraj Harmatha, Institute of Organic Chemistry and Biochemistry of the CAS; Ladislav Kohout, Institute of Organic Chemistry and Biochemistry of the CAS; Vojtech Spiwok, Institute of Chemical Technology in Prague ; Tomas Macek*, Institute of Chemical Technology in Prague

Different independent experiments proved the important role of some oxysterols in regulation of photosynthetic enzymes. Columns with immobilised oxysterols allowed us to isolate and identify in plant extracts proteins with affinity to these ligands. Testing the influence of the ligands on aktivity of the isolated proteins we found a new biological role of some oxysterols. Our results show that some brassinosteroids, ecdysteroids and their analogues act as effectors of activity of particular plant proteins. Some of the identified proteins play very important roles in plant organisms, *e.g*. in photosynthesis, or as pathogenesis-related proteins, the role of oxysterols in their regulation has to be clarified. The enzymes include among others ribulose1,5-bisphosphate carboxylase/oxygenase (RuBisCO), PsbP protein of the oxygen evolving complex of FS II or *e.g*. osmotin. The effect of oxysterols on photosynthetic activity of plants was analysed in several plant species, namely spinach, maize and tetragonia. Photosynthetic activity was examined at the level of oxygen production from leaf discs, photosystem II performance based on the detection of changes in chlorophyll fluorescence kinetics and the content of photosynthetic pigments. The influence of ecdysteroids on RuBisCO was studied using radioactively labelled CO^2. Our results show that different brassinosteroids, ecdysteroids and their synthetic analogues are able to increase oxygen production by water cleavage and the yield of RuBisCO-mediated reaction in which CO_2 is fixed into organic matter thus allowing fine tuning of the yield of photosynthesis.

Acknowledgement: The research was supported by grant P501/11/1650 of the Czech Science Foundation.

Keywords: RuBisCO, CO_2 fixation, oxygen evolving complex, ecdysteroids, brassinosteroids

* Tomas Macek, ICT Prague, Technicka 3, Prague 6, 16628 Czech Republic macekt@vscht.cz

Carbon Sequestration

Modeling carbon sequestration and mitigation of greenhouse gases in phytoremediation systems

Gayathri Gopalakrishnan*, Space Science Institute

Phytoremediation or contaminant removal using plants has been deployed at multiple sites to remediate contaminated soil and groundwater. Research has shown that plants are inexpensive alternatives to traditional remediation options such as pump-and-treat systems or soil excavation. In addition, plants sequester carbon through biomass accumulation and in their root systems and thus have the potential to act as carbon sinks. While studies have been conducted on the ability of plants to remediate contaminants, an analysis of the greenhouse gas emissions from typical phytoremediation systems is currently lacking. This study models carbon sequestration, nitrous oxide emissions and methane emissions from typical phytoremediation systems. Plants modeled include those most widely used in phytoremediation systems such as hyperaccumulators and woody trees. Model sensitivity to soil conditions, contaminant levels and local weather data and the resulting impacts on greenhouse gas emissions are explored. Tradeoffs between contaminant removal and mitigation of greenhouse gases are also evaluated.

Keywords: carbon sequestration, models

* Gayathri Gopalakrishnan, Space Science Institute, 4750 Walnut Street, Boulder, CO
ggopalakrishnan@spacescience.org, Phone: 720-663-0732

Carbon Sequestration

Integrated approach to long-term carbon sequestration and landslide mitigation using Vetiver Grass Model

Umesh C Lavania*, CSIR-Central Institute of Medicinal and Aromatic Plants

Vetiver grass, *Vetveria zizaniodes*, a perennial C_4 grass traditionally used for extraction of essential oil, has attracted world attention as a natural means for its multifarious environmental applications, including conservation and detoxification of degraded soil and water, flood and landslide disaster mitigation. The present author had proposed “vetiver grass model” for sequestration of atmospheric carbon into subsoil horizons to mitigate global warming likened to forest trees (*Curr. Sci.* **97**: 618-619, 2009). For global acceptance of this grass for environmental applications, a non-invasive seed infertile clone has been developed by the author (US Plant Patent www.google.com/patents/US20120278945), that promises carbon sequestration potential of 860g/square meter/year. Since this grass has tufted fibrous roots having physical strength comparable to 0.7 mm mild steal, therefore, in addition to its carbon sequestration potential it is an important candidate as a soil binder in landslide prone territories such as river banks and hill slopes. However, to make the vetiver plantations ecosystem sustainable it is desirable to develop designer genotypes that promise: (i) high carbon sequestration potential in sub-soil horizons, (ii) make it unattractive to local root diggers by minimising essential oil concentration in roots, (iii) sustain plantations mainly for root-growth potential but utilizing upper ground vegetative biomass as fodder (either by harvesting / natural grazing), and (iv) develop plantation strategies to terminate uncontrolled growth by excising the proliferating crown. Our scientific studies to realize such objectives will be presented to showcase the potential of Vetiver Grass Model in mitigating global warming, landslide disaster management vis-à-vis ecosystem services.

Keywords: Vetiver Grass Model, *Vetiveria zizaniodes*, Carbon sequestration, landslide management, soil conservation

* Umesh C Lavania, CSIR – Central Institute of Medicinal and Aromatic Plants, Lucknow 226 015, India lavaniauc@yahoo.co.in; lavania@cimap.res.in

Carbon Sequestration

Effects of Genotype and Environment on Carbon Sequestration of Hybrid Poplars in the North-Central USA

William L. Headlee*, Iowa State University, Ronald S. Zalesny Jr., U.S. Forest Service Northern Research Station,Richard B. Hall, Iowa State University, Edmund O. Bauer, U.S. Forest Service Northern Research Station, Bruce A. Birr, U.S. Forest Service Northern Research Station, Jesse A. Randall, Iowa State University, Adam H. Wiese, U.S. Forest Service Northern Research Station

Carbon sequestration in woody species is dependent upon both the amount of biomass produced and the carbon content of that biomass. Many studies focus primarily on biomass productivity, under the widely-held assumption that woody biomass is approximately 50% carbon by mass. As a result, there is a gap in our current knowledge about the potential genetic variability in the carbon content of woody biomass. In addition, the role of genotype × environment interactions on hybrid poplar biomass productivity (as well as the carbon content of that biomass) is poorly understood. Most reports are for a limited number of locations, resulting in a lack of information about the interactions between clones and sites over a wide range of climate and soil conditions. The objective of the current study was to characterize the effects of site, clone, and site × clone interactions on carbon sequestration (biomass production and carbon content) for 12 hybrid poplar genotypes grown at 17 sites in Iowa, Minnesota, Wisconsin, and Michigan, USA. Estimated biomass productivity varied by clone and by site (e.g. 2 to 6 Mg ha^{-1} yr^{-1} at Escanaba, MI, and 11 to 26 Mg ha^{-1} yr^{-1} at Ames, IA), while differences in carbon content among clones were observed at some sites (46% to 48% at Waseca, MN) but not others (all ~48% at Escanaba, MI). The results of the study are expected to be important for informing genotypic selection and management decisions associated with growing hybrid poplars for carbon sequestration, as well as other environmental services.

Keywords: biomass, clones, environmental services, *Populus*, short rotation woody crops

* William L. Headlee, 339 Science II, Ames, IA 50011, USA wheadlee@iastate.edu

Carbon Sequestration

Soil carbon sequestration: The need of hour

Pankaj Srivastava*, Eco-Auditing Group, CSIR-NBRI, Yogesh K Sharma, Department of Botany, Lucknow University, Nandita Singh, Eco-Auditing Group, CSIR-NBRI

There is a general consensus that increasing concentration of carbon dioxide (396.80 ppm) one of the serious environmental issues faced by humankind today. There is no doubt that the impact is severe, irreparable and implicated in the survival of human beings itself. Therefore, reducing the emission of trace gases responsible for green house effect is one of the important steps towards ecosystem sustainability. CO_2 is one of such major green house gases and unfortunately its concentration is increasing sharply. Therefore, biofuel plantations that can enhance soil C sequestration have attracted significant research attention. Results from field plantation at different types of soil showed that *jatropha curcas can* grow under minimal management practices. These studies provide useful data to establish relationship between nutrient availability, moisture holding capacity, and soil health as well as carbon sequestration potential of bioenergy crops. Long-term Jatropha plantation increased the Total organic carbon (TOC), Total Kjeldahl nitrogen (TKN), available phosphorus and potassium in the soil. Biofuel crops generate plausible changes in SOC, microbial biomass and enzyme pools. Jatropha accumulated and added to soil significant amounts of C ranges from (7.60 to 101.50 ton $ha^{-1}year^{-1}$) from the year one itself. Overall, 4th year old plantation added per year around 19.30 to 203.0 ton plant biomass equivalent to 1.30 to 10.15 ton C through the whole plant. It is suggested that jatropha plantation can be used to reclaim the degraded, marginal lands and reducing the release of greenhouse gases.

Keywords: Biofuel, Soil carbon sequestration, climate change,

* Pankaj Srivastava, Eco-Auditing Group, CSIR-National Botanical Research Institute(CSIR-NBRI), Council of Scientific & Industrial Research, Rana Pratap Marg, Lucknow 226 001, Uttar Pradesh, India pksnbri@gmail.com

15: Fate and Remediation of Emerging Pollutants

Fate and Remediation of Emerging Pollutants

Nitrogen and COD removal from ink-production wastewater by *Cyperus alternifolius* and microbial communities

Rujira Dolphen*, School of Bioresources and Technology, King Mongkut's University of Technology Thonburi, Paitip Thiravetyan, School of Bioresources and Technology, King Mongkut's University of Technology Thonburi

Phytoremediation was applied for the cleanup of ink-production wastewater. The wastewater contained complex compositions, high concentrations of organic matters, nitrogen compounds and colorants. This study was performed under various conditions; wastewater condition (control), soil-contained wastewater condition, plant grown in wastewater condition, and plant grown in soil-contained wastewater condition for 100 days. The pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) were investigated to study the relationship of biological processes under various conditions. The results could be explained with three stages. At stage I, nitrate was rapidly reduced at the lowest value while ammonium nitrogen also decreased. Using denaturing gradient gel electrophoresis (DGGE) confirmed that the microbial community was aerobic and had facultative-anaerobic groups. Sequencing of partial 16S rDNA revealed that the major groups included *Enterobacter*, *Pseudomonas*, *Stenotrophomonas* and *Azospirillum* which were responsible for denitrification. In stage II, it appeared that the remaining ammonium nitrogen concentration was reduced to a low content. In this stage, the plant grown in soil-contained wastewater condition could reduce NH_4^+-N, NO_2^--N, and NO_3^--N in about 26 days compared with other conditions which took longer (46 days). In addition, the nitrification of stage III still appeared to have low ammonium nitrogen and organic matter. This research revealed that plants could take up organic compounds continuously and over a prolonged period of time. The system of plant grown in soil-contained wastewater condition was revealed to be a sustainable system and the *C. alternifolius* plant was proved suitable to apply to ink-production wastewater treatment.

Keywords: phytoremediation, denitrification, nitrification, oxidation-reduction potential dissolved oxygen, denaturing gradient gel electrophoresis

* Rujira Dolphen, 49 Soi Thian Thale 25, Bang Khun Thian Chai Thale Road, Thakham, Bang Khun Thian, Bangkok 10150, THAILAND rdolphen@yahoo.com

Fate and Remediation of Emerging Pollutants

Translocation of Organic Compounds by Plants: Observations and Predictions

Matt Limmer*, Missouri S&T; Joel Burken Missouri S&T

Numerous emerging and fugitive compounds directly impact public health through passive uptake and translocation by plants, a process not thoroughly understood. Previous studies have indicated substantial variability, particularly for hydrophilic compounds. Applying approaches developed for drug discovery, compounds amenable to translocation by plants have a log K_{ow} of less than 5, a molecular mass of less than 300 Daltons, 3 or fewer hydrogen bond donors, and 7 or fewer hydrogen bond acceptors. Considering these cutoffs and cutoffs for rotatable bonds and polar surface area, chemical transport through roots is shown herein to resemble permeability of the blood-brain barrier to a greater degree than intestinal membrane permeability. The physicochemical domain allowing plant translocation of environmental contaminants is a critical tool in preliminary exposure screening of emerging contaminants and provides insight for the use of plants in remediation and sensing of such contaminants. In addition, the physicochemical properties identified herein were used to generate a predictive model of the TSCF. Monte Carlo analysis also identified that the TSCF was highly sensitive to changes in transpiration rate, indicating experimental arrangement can significantly impact findings.

Keywords: emerging contaminants, TSCF, QSAR

* Matt Limmer, 1401 N. Pine St, Rolla, MO 65409 limmer.7@gmail.com

Fate and Remediation of Emerging Pollutants

Pharmaceuticals in the environment
Model study of *in vitro* phytoextraction from aquatic media

Stanislav Smrcek*, Alice Chupikova, Dominika Luptakova, Veronika Doubnerova, Helena Ryslava and Sarka Psondrova, Charles University in Prague, Faculty of Science

The presence of pharmaceuticals and their metabolites is a serious worldwide problem. The efficiency of sewage treatment plants in their removal from municipal wastewaters is not sufficient and the substances can contaminate not only aquatic environment but also the terrestrial organisms. Phytoremediation technology seems to be a possible decontamination method for this purpose however the theoretical studies about the fate and physiological changes in plants are necessary. In model system of sterile, hydroponically cultivated *Zea mays* and *Helianthus annuus* plants the interaction of commonly used pharmaceuticals acetaminophen, ibuprofen, carbamazepine and its metabolite 10,11-epoxycarbamazepine was studied to investigate the uptake and the influence on plant metabolism. Analgesic drug diclofenac was tested for uptake and translocation using radioactively labeled (125-I) analogue. Ibuprofen, acetaminophen and diclofenac were effectively extracted from drug supplemented media by both plants, carbamazepine and 10,11-epoxycarbamazepine were significantly less extracted. The translocation study with radiolabeled diclofenac using electronical autoradiography showed, that transport to the shoot part of plants is possible. The effect of studied pharmaceuticals on plant metabolism was followed. The activity of phosphoenolpyruvate carboxylase, NADP-malic enzyme and pyruvate, phosphate dikinase was evaluated.
The most enhanced activity of PEPC and NADP-ME was found in maize roots in the presence of acetaminophen, carbamazepine and its metabolite. Some isoenzymes of peroxidases were also affected.
The obtained results show that the influence of tested pharmaceuticals on the plant metabolism and their uptake by root system are dependent on the chemical structure of contaminant, plant species, and on the type of carbon dioxide fixation.

Keywords: phytoremediation, pharmaceuticals in the environment, water cleaning

*Smrcek Stanislav, Charles University in Prague, Faculty of Science, Albertov 6, 12843 Prague, Czech Republic, smrcek@natur.cuni.cz

Susceptibility of Riparian Wetland plants to Perfluorooctanoic acid (PFOA) Accumulation

John Baptist Mudumbi*, CPUT; Karabo Ntwampe, CPUT; Munyololo Muganza, IThemba Labs; Jonathan Okonkwo, TUT

As plants have been shown to accumulate organic compounds from contaminated sediments, there is a potential for long-lasting ecological impact as a result of contaminant accumulation in riparian areas of wetlands, particularly the accumulation of non-biodegradable contaminants such as perfluorooctanoic acid (PFOA). In this study, commonly found riparian wetland plants including reeds, i.e., *Xanthium strumarium, Phragmites australis, Schoenoplectus corymbosus, Ruppia maritime; Populus canescens, Polygonum salicifolium, Cyperus congestus; Persicaria amphibian, Ficus carica, Artemisia schmidtiana, Eichhornia crassipes*, were studied to determine their susceptibility to PFOA accumulation from PFOA contaminated riparian sediment with a known PFOA concentration, using liquid chromatography/tandem mass spectrometry (LC/MS/MS). The bioconcentration factor (BCF) indicated that the plants affinity to PFOA accumulation was; *E. crassipes, > P. salicifolium, > C. congestus, > P. x canescens, > P. amphibian, > F. carica, > A. schmidtiana, > X. strumarium, > P. australis, > R. maritime, > S. corymbosus.* The concentration of PFOA in the plants and/or reeds was in the range 11.7 to 38 ng/g, with a BCF range of 0.05 to 0.37. The highest BCF was observed in sediment for which its core water had a high salinity, total organic carbon and a pH which was near neutral. As the studied plants had a higher affinity for PFOA, the resultant effect is that riparian plants such as *E. crassipes, X. strumarium,* and *P. salicifolium*, typified by a fibrous rooting system, which grow closer to the water edge, exacerbate the accumulation of PFOA in riparian wetlands.

Keywords: perfluorooctanoic acid (PFOA); perfluorinated compounds; wetland plants; reed grass; bioconcentration factor (BCF).

* John Baptist Mudumbi, Cape Peninsula University of Technology (CPUT) Faculty of Applied Sciences Department of Environmental &Occupational Studies Cape Town Campus Cnr Keizersgracht & Tennant Street, Zonnebloem, 8001 Science Building Room 3.56 jbmudumbi@gmail.com / mudumbij@cput.ac.za

Long-Term Variation of Chlorinated Solvents in Trees

Matt Limmer, Missouri S&T; Amanda Holmes*, Missouri S&T; Joel Burken Missouri S&T

Trees are able to pump, store and remove contaminants from the subsurface, making plants not only remediation tools, but also attractive supplements to traditional methods for long-term monitoring of chlorinated solvent plumes, a practice termed "phytomonitoring". However, the pumping rate of trees is dependent on environmental conditions, resulting in variable *in planta* concentrations and contaminant removal rates. This project used *in planta* solid-phase microextraction (SPME) coupled with gas chromatography (GC) to measure chlorinated solvent concentrations in four trees at a contaminated site in Rolla, Missouri. A single measurement could be made in less than twenty minutes, with ten minutes of that time required for transportation to and from the GC. All concentrations were corrected for temperature-dependent partitioning differences. The sampling ports in each tree have provided more than 100 samples per tree over a three-year period. Concentrations in the tree exhibited a seasonal trend, with highest concentrations observed during the summer months, when translocation of groundwater was highest. Peak concentrations measured in the summer were approximately one order of magnitude higher than minimum concentrations measured in the winter and were correlated with estimates of evapotranspiration (ET) based upon local weather. New methods of modeling contaminant removal rates were generated using ET estimates and *in planta* concentrations. This modeling approach and *in planta* measurements offers a new method to project mass removal rates for phytoremediation of organic contaminants.

Keywords: Phytomonitoring, *in planta* sampling, SPME

* Amanda Holmes, 1401 N. Pine St, Rolla, MO 65409 mailto:burken@mst.edu

16: Plant Nano Particle Interactions

Plant Nano Particle Interactions

Accumulation of engineered nanoparticles in plant foods: Nutritional bioaccessibility and dietary exposure risks

Stephen Ebbs*, Department of Plant Biology and Center for Ecology, Southern Illinois University Carbondale; Scott Bradfield, Department of Plant Biology, Southern Illinois University Carbondale; Pawan Kumar, Department of Plant Biology, Southern Illinois University Carbondale; Xingmao Ma Department of Civil and Environmental Engineering, Southern Illinois University Carbondale

The release of engineered nanomaterials (ENMs) into the environment has raised serious concerns about their potential risks to food safety and human health. There is a particular need to determine the extent of ENM uptake into plant foods. Two set of studies are underway to evaluate the ENM accumulation in various plant foods. A systematic evaluation of the accumulation of six different ENMs into the tissues of ten common below ground vegetables is underway to identify those with the greatest potential for ENM accumulation. Additional efforts will use the vegetables produced to examine how basic food preparation steps alter ENM dietary exposure and to estimate the nutritional bioaccessibility of the ENMs from those tissues. Separate studies are utilizing leaf and stem vegetables and a limited array of seed crop species to examine how modes of ENM exposure promote accumulation in edible tissues. Dietary exposure modeling is being planned for all of the plant species under study to quantify risks of ENM exposure. The nutritional bioaccessibility of the ENM will be demonstrated and models projecting dietary exposures will be produced to provide a comprehensive picture of the food safety risk posed by these ENMs. Results from this work are expected to help growers, extension agents, and government agencies to make sound decisions on choice of crops for particular ENM-impacted soils. The specific accumulation and dietary exposure scenarios associated with particular ENM and plant combinations would allow for recommendations concerning which ENM-containing products can be safely applied to human food crops.

Keywords: engineered nanoparticles, food safety, phytotoxicity, dietary exposure

* Stephen Ebbs, 420 Life Science II, 1125 Lincoln Dr., Carbondale, IL, 62901-6509
sebbs@plant.siu.edu

Plant Nano Particle Interactions

Toxicogenomics of CdS nanomaterials in *Arabidopsis thaliana* and *Saccharomyces cerevisiae*

Luca Pagano, Marta Marmiroli*, Maria Luisa Savo Sardaro, Nelson Marmiroli - Department of Life Sciences, University of Parma

Nanotechnology is a rapidly growing industry and engineered nanomaterials (ENMs) are applied in several areas such as electronics, biomedicine, pharmaceuticals, cosmetics, food production. The scarce knowledge about uptake, interaction with cells, toxicity, is hindering the full application of ENMs, as shown by recent decisions of the European Commission and European Food Safety Authority. The aim of this work was to develop a toxicogenomics approach for risk assessment of ENMs, focusing on quantum dots cadmium sulfide nanoparticles (CdS NPs) using *Arabidopsis thaliana* (L.) Heynh and the yeast *Saccharomyces cerevisiae* as model systems. Two mutant lines of Arabidopsis have been selected as resistant to lethal concentrations of CdS NPs, and the phenotypes and genotypes have been extensively characterised. The global gene expression profile in the two mutants has been analysed using Affymetrix GeneChip Arabidopsis ATH1 Genome Array, showing differences in the panel of induced and repressed genes. The approach in yeast is based on a collection of 6000 haploid strains carrying deletions in genes which are not essential for survival. Resistance (or hypersensitivity) to CdS NPs exhibited by a specific strain suggests that the gene deleted in that strain plays a role in the phenotype. Genes identified in the two model systems are currently being characterised in experimental treatments.
The two toxicogenomics approaches can therefore provide information on biological mechanisms and pathways involved in nanomaterials effects on living cells.

Keywords: nanotoxicology, engineered nanomaterials, quantum dots, toxicogenomics

* Marta Marmiroli, Parco Area delle Scienze 33A, 43124 Parma,Italy marta.marmiroli@unipr.it

Plant Nano Particle Interactions

Wetlands and phytoremediation of nanoparticle metals

Donna L. Jacob*, Marinus L. Otte, Joshua Borchardt, Wet Ecosystem Research Group, Department of Biological Sciences, North Dakota State University; Achintya Bezbaruah, Nanoenvirology Research Group, Department of Civil Engineering, North Dakota State University

Because nanoparticles are making their way into watersheds and aquatic systems, and are known to affect organisms including plants, animals, and microbes, it is imperative we understand nanoparticle behavior in wetlands. For wetland plants, and particularly from a phytoremediation perspective, there are significant gaps in our knowledge. Some researchers have found interactions between important biological characteristics of wetlands and nanoparticles, including toxicity to microbes, solubility with natural dissolved organic matter, and dissolution behavior with phytosiderophores. Our research on two common wetland plants, *Rumex crispus* and *Elodea canadensis,* grown in nutrient solution containing titanium dioxide nanoparticles, is presented here. These plants showed uptake and translocation of nanoparticle titanium into the tissues, and interactions with phosphorus in the growth medium. Our research raises questions about how plant macronutrients interact with metal-nanoparticles under field conditions.

Keywords: titanium dioxide, uptake, wetland plants

* Donna L. Jacob, Wet Ecosystem Research Group, North Dakota State University Dept. 2715, PO Box 6050, Fargo, ND 58108-6050 donna.jacob@ndsu.edu

Plant Nano Particle Interactions

Changes in *Arabidopsis thaliana* gene expression in response to silver nanoparticles and silver ions

Benoit Van Aken*, Temple University; Rashid Kaveh, Temple University; Sibia Ranjbar, Temple University

Silver nanoparticles (SNPs) are widely used nanomaterials that have raised environmental concerns because of their toxicity to most living organisms, including plants. However, little is known about the effects of SNPs on plants at the molecular level. In this study, *Arabidopsis thaliana* plants were exposed to SNPs (20 nm diameter) and silver ions (Ag^+) and the effects on gene expression were investigated using cDNA genome-wide microarrays. Although exposure of *Arabidopsis* plants to low concentration of SNPs (1 mg L^{-1}) showed a slight increase of the biomass after 14 days, exposure to higher concentrations (5 mg L^{-1} and higher) resulted in a significant decrease of the biomass, as compared to non-exposed controls. On the other hand, plants grown in the presence of soluble silver (Ag^+) at concentrations above 2.5 mg L^{-1} showed a significant reduction of the biomass after 14 days, as compared to non-exposed controls. Exposure of *Arabidopsis* plants to SNPs and Ag^+ at the concentration of 5 mg L^{-1} for 14 days resulted in differential expression of many genes involved in response to stress and response to biotic and abiotic stimuli. Although distinct gene expression patterns developed upon plant exposure to SNPs and Ag^+, a significant overlap of differential expressed genes was observed between the two treatments (16% of the 50 most down-regulated and 41% of the 50 most up-regulated genes were detected in both SNPs and Ag^+ exposed plants). These results strongly suggest that SNP-induced stress originates partly from silver toxicity and partly from nanoparticle-specific effects.

Keywords: Silver nanoparticles, silver, *Arabidopsis thaliana*, gene expression, microarray

* Benoit Van Aken, Department of Civil and Environmental Engineering, Temple University, 1947 N. 12th Street, Philadelphia, PA, bvanaken@temple.edu

Plant Nano Particle Interactions

Multi-generational Impact of Cerium Oxide Nanoparticles on Plant Growth and Oxidative Stress of *Brassica rapa*

Qiang Wang, Civil and Environmental Engineering, Southern Illinois University Carbondale,
Xingmao Ma*, Civil and Environmental Engineering, Southern Illinois University Carbondale

Cerium oxide nanoparticles (CeO_2-NPs) have been incorporated into many commercial products and their continued release to the environment through the life cycle of these commercial products has attracted increasing concerns. Consequently, the impact of CeO_2-NPs to the environmental health, including their impact to plants has been broadly examined. However, the long term impact of CeO_2-NPs, and their implications to plant health and food safety remains unsettled. The main objective of this study was to investigate whether continued irrigation with solutions containing different concentrations of CeO_2-NPs (0, 10, 100 and 1,000 mg/L) through several generations would alter the physiological and biochemical responses of *Brassica rapa* to CeO_2-NPs. Three generations of *Brassica rapa* were grown and with each generation, the phenotypic development was monitored throughout the life cycle of plant development. The seeds from each generation were collected and germinated to obtain young seedlings stretching four generations at the same time. After the seedlings were irrigated similarly as their mother plants and gained enough biomass, Hydrogen peroxide (H_2O_2) as a representative Reactive Oxygen Species (ROS) was determined in plant tissues. The activity of two enzymatic antioxidants intimately involved in the generation and detoxification of H_2O_2 was also determined. The results suggested that plant response to CeO_2-NPs showed generational patterns and long term evaluation on the phytotoxicity of engineered nanomaterials to plants needs further investigation.

Keywords: cerium oxide nanoparticle, oxidative stress, ROS, multigenerational impact

* Xingmao Ma, 1230 Lincoln Drive, MC 6603, Carbondale, IL ma@engr.siu.edu

Plant Nano Particle Interactions

Phytotechnology for Synthesis of Nanoparticles

Shivendra Sahi*, Biology Department, Western Kentucky University,; B. Sinilal, Biology Department, Western Kentucky University; Ajay Jain, Biology Department, Western Kentucky University; Dan Starnes, Biology Department, Western Kentucky University

Nanotechnology is a fast growing field of generating a myriad of nanomaterials at nanoscale, thereby conferring them unique optoelectronic and physicochemical attributes. It has found applications in medicine, consumer goods, heavy industry, information and communication, optoelectronic devices, environment-friendly energy system, and chemical catalysis. Traditionally, wet synthesis of nanoparticles requires industrial processing involving chemicals, and thereby generating hazardous byproducts, which has triggered the concerns on the environment. To circumvent deleterious effects of nanomaterial manufacturing by wet synthesis, "green synthesis" of nanogold particles by biological organisms provides an environment-friendly and economically viable alternative. Certain plant species have the ability to incorporate remarkably high levels of heavy elements into their tissues. We used X-ray absorption near edge spectroscopy to demonstrate the *in planta* ability to reduce more than 80% of $KAuCl_4$ into Au^0 nanoparticles (AuNPs) ranging in size from 10-50 nm exhibiting *in situ* catalytic function. Efforts are now under way to decipher the molecular mechanism governing the uptake and mobilization of AuNPs in plants.

Keywords: nanotechnology, gold nanoparticles, green synthesis of nanoparticles

* Shivendra Sahi, Biology Department, Western Kentucky University, Bowling Green, KY
shiv.sahi@wku.edu

17: Soil and Carbon Amendments

Biochar application on hazardous materials: Variation in contaminants distribution and availability on polluted matrices

Guido Fellet*, UNIVERSITY OF UDINE; Filip Pošćić, UNIVERSITY OF UDINE; Luca Marchiol, UNIVERSITY OF UDINE;

Biochar has been attracting a great deal of interest as a possible solution to promote carbon sequestration in the attempt to mitigate global warming. Such C rich product has recently been considered as a potential amendment for polluted sites. Its high density of exchange sites makes it an interesting material for the immobilization of a wide range of pollutants, both organics and inorganics. The effects on soil have been widely described; they regard most of the physical and chemical properties from pH and EC to water retention and CEC. These effects change the fertility of the soil and can significantly reduce the phytotoxicity of polluted matrixes such as the industrial and mine wastes. The application of biochar can bring nutrients, increase the water availability and reduce the bioavailability of some heavy metals.

Laboratory characterizations were performed to describe the effects of the application of three types of biochar produced by pyrolysis of three feedstocks (pruning residues, manure pellets and fir wood pellets) to two types of heavy-metals-rich wastes (industrial wastes and mine tailings) at the dose of 3% dry weight. Data from sequential extractions will be presented to describe the variations of the partitioning for Cd, Cu, Ni, Pb and Zn. A soil-packed-lysimeter experiment showed the influence of the biochars on the leachability of the pollutants that increased for Pb while decreased for others (i.e. all the biochars reduced Cd leachability in both the materials). Contaminants bioavailability will also be presented in the perspective of the future application of plants on the polluted wastes.

Keywords: biochar, industrial wastes, heavy metals.

* Guido Fellet, Department of Agriculture and Environmental Sciences, University of Udine Via delle Scienze 206, 33100 Udine (Italy), guido.fellet@uniud.it

Soil and Carbon Amendments

Interpreting Hybrid Poplar Responses to Soil and Foliar Applications of Bioenergy Byproducts via Vector Analysis

William L. Headlee*, Iowa State University; Richard B. Hall, Iowa State University; Ronald S. Zalesny Jr., U.S. Forest Service Northern Research Station

As renewable energy technologies continue to develop for converting biomass into bioenergy and biofuels, finding safe and effective applications for byproducts is increasingly important. Biochar (produced from pyrolysis of biomass) is potentially useful for increasing the cation exchange capacity of soils, and fly ash (produced from direct combustion of biomass) can be used as a liming agent and a source of several plant nutrients. However, difficulties are often encountered in spreading these materials evenly on fields, as well as preventing the material from being transported from the site by wind and water. In addition, the complexity of plant responses to such applications often makes study results difficult to interpret. These challenges may be overcome with innovative approaches for utilizing bioenergy byproducts, as well as specialized methods for interpreting the results. The purpose of this presentation is to describe (1) the results of two separate studies in which novel applications of biochar and fly ash were tested with hybrid poplar, and (2) the utility of vector analysis for interpreting these results. In the first study, biochar was tested as a substitute for vermiculite (an expensive and non-renewable input for the greenhouse industry) in potting mix for hybrid poplar. In the second study, suspensions of fly ash were tested as foliar fertilizer for hybrid poplar in greenhouse and field settings. Vector analysis, in conjunction with traditional statistical analysis, was found to be an extremely useful tool for interpreting treatment effects on plant nutrient availability, uptake, and growth in both studies.

Keywords: ash, biochar, bioenergy, *Populus*, sustainability

* William L. Headlee, 339 Science II, Ames, IA 50011, USA; wheadlee@iastate.edu

Soil and Carbon Amendments

Using Phyto-Recurrent Selection to Identify Favorable *Populus* Genotypes Grown in Biochar-Amended Soils

Ronald S. Zalesny Jr.*, U.S. Forest Service, Northern Research Station; William L. Headlee, Iowa State University; Deborah S. Page-Dumroese, U.S. Forest Service, Rocky Mountain Research Station

Biochar is a value-added byproduct of the bioenergy industry that contributes to sustainability of the energy supply chain. Headlee et al. (2013) reported that biochar provided similar benefits to hybrid *Populus* clone 'NM6' in terms of nutrient availability and growth when substituted for vermiculite in greenhouse production. We are currently using phyto-recurrent selection to choose *Populus* clones that exhibit greater survival and growth when grown in biochar-amended soils versus those containing vermiculite or no soil amendments. Using three phyto-recurrent selection cycles, we have reduced a base population of 61 genotypes (cycle 1) to 30 (cycle 2) in the greenhouse, and will be advancing 10 clones to field testing during cycle 3. Our specific objectives are to test for differences among: 1) soil treatments (100% peat, 75% peat + 25% vermiculite, 75% peat + 25% biochar) for chemical properties (pH, CEC, ECEC) and nutrient content (total N, P, and exchangeable K, Ca, Mg, and Na), 2) *Populus* genotypes for survival, growth and biomass, and uptake of nutrients (N, P, K, Ca, Mg, Na) into roots, stems, leaves, and cuttings, and 3) their interactions. To date, we have completed cycle 1 and have used a multiplicative rank summation index (based on weighted allometric traits and survival) to identify the top 30 genotypes to advance to cycle 2 during spring 2013. Cycles 2 and 3 will be completed in summer 2013 and results for all objectives will be presented.

Keywords: biomass and bioenergy, clonal selection, hybrid poplar, plant propagation, plant uptake

* Ronald S. Zalesny Jr., Institute for Applied Ecosystem Studies, 5985 Highway K, Rhinelander, WI 54501, USA; rzalesny@fs.fed.us

Soil and Carbon Amendments

Uptake of heavy metals by three tropical native plants exposed to landfill leachate

E. Peña-Salamanca, Universidad del Valle, Biology Department*; C.A. Madera-Parra, Universidad del Valle, EIDENAR School; M.R. Peña, Universidad del Valle, CINARA Institute

This study assessed the uptake of Cd^{2+}, Hg^{2+}, Pb^{2+} and Cr^{6} in native tropical plants (*Gynerium sagittatum (Gs), Colocasia esculenta (Ce)* and *Heliconia psittacorum (He))* planted in sub-surface horizontal flow constructed wetlands treating synthetic landfill leachate (LL), after 60 days of operation. The experiment was factorial design with two factors: i) plant species and ii) Heavy Metal (HM) concentration. 16 CW (0.60 x 0.30 x 0.50 m in length, width and height, respectively) were arranged in two experimental blocks. Metal concentrations in the influent, effluent, root, stem, branch and leaves of native plants were analysed. COD, $N\text{-}NH_4^+$, TKN T, pH, ORP, DO & EC were analysed. The CW´s showed good removal capacity for all pollutants. Average removal of COD, TKN and $N\text{-}NH_4^+$ were 66, 67 and 72% respectively for both treatments. 92-98% for both treatments was the removal efficiency of HM in all units. Cr (VI) was not detected in any effluents samples. Bioaccumulation factors (BAF´s) of HM in the natives plants were 10^0 -10^2. BAF of Cr (VI) was lower: 0,59 y 2,5 (L kg^{-1}) for *Gs* y *He* respectively, and Cd (II) was the higher (130 - 135 L kg^{-1}) *Gs*. Regarding with accumulated HM, roots generally showed higher metals content than shoots. Translocation factor (TFs) were lower, *He* was the plant with TFs >1 in three HM, and 0,4-0,9 for the others. The evaluated natives plant do not reached the threshold to be consider hyper-accumulator but showed good performance and all can be categorized as accumulators.

Keywords: Bioaccumulation; landfill leachate, heavy metals, phytoremediation

* E. Peña-Salamanca, Universidad del Valle, Biology Department, Calle 13 #100-00 A:A 25360 Cali, Colombia. Enrique.pena@correounivalle.edu.co

Soil and Carbon Amendments

In situ Application of Activated Carbon and Biochar to Minimize PCB Bioavailability

Mackenzie J. Denyes*, The Royal Military College of Canada; Dr. Barbara A. Zeeb, The Royal Military College of Canada; Dr. Allison Rutter, School of Environmental Studies, Queen's University

The use of carbon amendments such as activated carbon (AC) and biochar to immobilize organic contaminants *in situ* is gaining in popularity. To date, most studies have focused on AC and there is less data available for biochar, which is a greener more cost-effective material. In the first *in situ* experiment conducted at a Canadian PCB-contaminated Brownfield site, AC and two types of biochar performed equally well at reducing PCB uptake into plants. However, in a similar *in situ* field experiment, conducted the following year at Point Pelee National Park (PPNP) in Leamington, Ontario, neither the two types of biochar nor AC were successful in minimizing DDT bioavailability. Our supporting greenhouse work has shown that when carbon amendments are mechanically mixed with contaminated soil, plant shoot and root and worm contaminant concentrations are respectively 66%, 59% and 39% lower than in the manually mixed treatments. Thus although AC and biochar show significant potential to serve as sorbents for the *in situ* stabilization of organic contaminants, future research should focus on environmentally relevant application methods to better determine the actual remediation potential of these materials under field conditions. A second *in situ* experiment which will be conducted at PPNP this upcoming summer, focusing on the effects mixing techniques, will also be discussed.

Keywords: biochar, activated carbon, phytoextraction, persistent organic pollutants, bioavailability

* Mackenzie J. Denyes, Department of Chemistry and Chemical Engineering, Royal Military College of Canada, Kingston, ON, Canada K7K 7B4 mackenzie.denyes@rmc.ca

Soil and Carbon Amendments

Impact of Bio-Char Addition to Soil on Weathered *p, p'*–DDE Accumulation in Zucchini Plants

Mehmet Isleyen*, Sakarya Univ.; Jason C. White, Ct Aes; Pinar Sevim, Duzce Univ.; Gazel Oykum Ozdemir, Sakarya Univ.; Nilsu Keskin, Sakarya Univ.; Bengu Nihan Gur, Sakarya Univ.; Sumeyye Akarsu, Sakarya Univ.; Yigit Temel, Sakarya Univ.; Deniz Delikaya, Sakarya Univ.; Seyma Z. Kilinc, Sakarya Univ.

Pot experiments were conducted to assess the effect of bio-char (BC) amendment on the phytoextraction of weathered p,p-dichlorodiphenyldichloroethane (*p,p'*-DDE) from soil by plant systems. Soil contaminated with 150-190 ng/g *p,p'*-DDE was amended with bio-char at 0, 0.1, 1.0, and 10% (w/w) levels and *Cucurbita pepo* (cv Raven) was then planted. The plants were harvested after 30-day of growth and *p,p'*-DDE concentrations were measured in roots, shoots, and leaves. Soil pH values were measured before planting and at harvest. Before planting, soil pH in the absence of biochar was 7.08; biochar amendment decreased the soil pH to 6.26. At the end of the experiment, the average pH value for all pots was significantly increased at 7.25. The amount of *p,p'*-DDE accumulated in roots and shoots of the plants decreased significantly with increasing amounts of bio-char. At the 0%, 0.1%, 1%, and 10% amendment levels, *p,p'*-DDE concentrations in roots were 5910 ng/g, 5710 ng/g, 1630 ng/g, and 340 ng/g, respectively. Shoot *p,p'*-DDE concentrations followed a similar decreasing pattern of contaminant burden with increasing biochar exposure. Average *p,p'*-DDE concentration in the shoots of plants grown with 10% BC was reduced by 87% relative to control plants. Leaf concentrations of *p,p'*-DDE ranged from 6.26 ng/g to 8.29 ng/g and were not affected by biochar exposure. The potential use of biochar for reducing pesticide residue levels in food crops will be discussed

Keywords*:* *p,p'*-DDE, zucchini, biochar, accumulation

* Mehmet Isleyen, Sakarya University, Department of Environmental Engineering Esentepe Campus, Sakarya 54187, TURKEY, (+90) 264-295-5638, mehmet.isleyen@gmail.com

18: Storm and Wastewater

Storm and Wastewater

Design and Testing of a Wastewater Irrigation System for Pilot-Scale Poplar Tree Nitrogen Processing Studies

Hayden Ausland*, The University of Iowa Department of Civil and Environmental Engineering; Craig Just, The University of Iowa Department of Civil and Environmental Engineering; Louis Licht, Ecoloree, Inc.

Land application of wastewater is a common reuse practice implemented in agricultural watersheds. The Port of Morrow has been managing and land applying approximately 180 million gallons of industrial food processing wastewater each year as a method of wastewater treatment and as a supplemental agricultural fertilizer in the Lower Umatilla Basin of Eastern Oregon. Recent groundwater analysis reports from the Oregon Department of Environmental Quality have shown increasing trends of nitrate concentrations in many of the well networks throughout the Lower Umatilla Basin, exceeding the local 7 mg/L Groundwater Management Area trigger levels. Nitrate concentrations sampled from the monitoring wells located near the sites where land application occurs range from less than 0.02 mg/L to 129 mg/L NO_3^-–N with average concentrations between 0.2 mg/L and 63.3 mg/L NO_3^-–N. A pilot study at the University of Iowa will determine how Oregon soils planted with poplar trees and amended with sawdust, manure and vermiculite impact the sorption of ammonia and affect nitrate denitrification in the root zone dosed with wastewater during plant dormancy. A synthetic wastewater has been developed at the University of Iowa to mimic that which is land applied by the Port of Morrow and is currently being dosed (0.5 gallons/d) onto poplar tree test cells within a cooler at a temperature of 40^{o}F. The results of this study will help determine the extent of nitrogen processing potential of hybrid poplars on a large scale basis.

Keywords: nitrate, denitrification, test cell, wastewater, land application

* Hayden Ausland, 4105 Seamans Center for the Engineering Arts and Sciences, Iowa City, Iowa, 52242 hayden-ausland@uiowa.edu

Storm and Wastewater

Year-round Field-Scale Waste Water Treatment based on Phyto Processes

Licht Louis*, Ecolotree Inc; English Marshall, Oregon State University; Just, Craig, The University of Iowa and Ausland, Hayden, The University of Iowa

Plants and their associated microbes have cycled elements since geologic time - called Nature. Regulated 'pollutant' nitrogen in waste water naturally cycles through all plant-rooted soil reactors. Active photosynthesis feed roots and microbes while nutrients and water are extracted. Rhizosphere reactions change with no transpiration in winter. Winter phyto requires sufficient treatment so percolating water achieves a permitted discharge to the aquifer.
Port of Morrow at Boardman OR is an important economic job engine in North Central Oregon. By 2015, daily waste water flow from food processors will be 6.5 million gallons averaging 115 PPM protein nitrogen (TKN). In the past 30 years, this effluent was irrigated on 5000 cropped acres at 'agronomic rates'. To protect the regional water, Oregon Department of Environmental Quality state issues the land application discharge permit based on these water and nitrogen agronomic rates for irrigated crops established by Oregon State University scientists.
The Phyto approach takes into account microbial nitrogen-consuming reactions including nitritation, denitrification, denitritation, and deamination. When accounted in the land applied nitrogen budget, rhizosphere processes remove a predictable nitrogen dose year-round. Crops like poplar & alfalfa grow a perennial root system with longer dwell time and more complete treatment. In 2013, a 24-acre EBuffer poplar plot was planted with 13,400 trees. Controlled variables include waste water dose, chemistry, variety, slope, and cropping techniques. Data are fundamental for the full-scale ODEQ permit requiring 500+ acres of poplar by winter 2016.

Keywords: wastewater, denitrification, rhizosphere, soil variability, poplar, irrigation

* Licht Louis, Ecolotree Inc., North Liberty IA, 52317 lou-licht@ecolotree.com

Storm and Wastewater

Pig slurry treatment using bamboo plantations: Plant response and treatment efficiency

Julien Piouceau*, Phytorem S.A.; Grégory Bois, Phytorem S.A.; Matthieu Anastase, Phytorem S.A.; Frédéric Panfili, Phytorem S.A.; Frédéric Feder, CIRAD; Julien Morel, CIRAD; Laurent Dufosse, Université de La Réunion; Véronique Arfi, Phytorem S.A.

On the Reunion Island, a French overseas territory, the increase of the pig farming generates large amounts of slurries. Due to the insular context, most of pig slurries are spread on small agricultural land areas. To reduce the risk of eutrophication of the water resources, phytoremediation appears as an attractive option for the pig slurry treatment. A treatment system using bamboo plantations was assessed during two years. Three field plots were implemented on a 600 m^2 area. Forty bamboo clumps were planted on each plot. A total of 67 m^3 of pig slurry were spread on two plots, under two forms: raw and centrifugal slurry. The total amount of nitrogen, phosphorus and potassium applied on the plots was 5.3, 1.4 and 5.5 $t.ha^{-1}$ respectively for the raw slurry treatment, and 4.2, 0.4 and 5.1 $t.ha^{-1}$ respectively for the centrifugal slurry treatment. The third plot was watered only with tap water (control). The response of bamboo species to pig slurry application was determined using morphological parameters, Chlorophyll *a* fluorescence measurements and biomass yield. The biomass increased by 1,8 to 6 times compared to the control, depending on the species and the form of slurry. Depending on the species, the average biomass yielded after 2 years ranged from 52 to 135 $t.DM.ha^{-1}$. In comparison to the initial concentrations in the slurries, the nitrogen concentration in drainage water was decreased by 97.2 and 98.6%, the phosphorus by 99.6 and 99.9% and the potassium by 83% and 99%, for the raw and centrifugal slurry respectively.

Keywords: pig slurry, bamboo, biomass, soil, eutrophication

* Julien Piouceau, PHYTOREM SA, chemin de l'autodrome, 13140 MIRAMAS, France, julienpiouceau@phytorem.com

Storm and Wastewater

The “Bambou-Assainissement®”: a phytoremediation technology combining the wastewater treatment and the production of high added value biomass

Frédéric Panfili*, Phytorem S.A.; Julien Piouceau, Phytorem S.A.; Charles Perrin, Phytorem S.A.; Véronique Arfi, Phytorem S.A.

Phytorem is a French company which has developed a phytoremediation based-technology using bamboos to remediate wastewater. This water treatment process named “Bambou-Assainissement®” was patented in 2002. Briefly, the treatment consists in spreading the wastewater on a plantation of selected bamboo species, sized according to the kind of wastewater, the soil properties and the climatic conditions of the site. The treatment process has been validated for agricultural effluents (winery effluent and olive mill oil wastewater) by the French water Agency in 2004 and 2009. The Bambou-Assainissement® is also used for the sanitation of domestic wastewater. In 2010, in the frame of a European eco-innovation program, we adapted our process for the treatment of industrial organic wastewater, by planting selected bamboo species in filtration media instead of planting in soil. Currently, there are about 40 Bambou-Assainissement® sites in France, including all kind of wastewater and all kind of treatments (plantation on soil or in filtration media). This phytoremediation treatment can be considered both as an efficient wastewater treatment site, and also as a biomass production site. Indeed, when a bamboo plantation reaches its maturity (after 5 - 7 years), it can yield from 10 to 50 T of dry matter.$ha^{-1}.yr^{-1}$ depending on the climate and depending on the bamboo species. Bamboo is also an aesthetic plant, allowing good landscape integration. Finally, the Bambou-Assainissement® is well adapted for rural areas and for developing countries, because even if engineering and scientific expertise are needed, it remains a rustic technology.

Keywords: wastewater, bamboo, biomass, soil, filtration media

* Frédéric Panfili, Phytorem S.A., chemin de l’autodrome, 13140 MIRAMAS, France, fredericpanfili@phytorem.com

Storm and Wastewater

Greening Of A Smelter For Sustainable Stormwater Management

Amanda Ludlow*, Roux Associates, Inc.

Roux Associates recently completed installation of a multi-faceted Engineered Natural System (ENS®) for the treatment and management of stormwater runoff from a 200-acre metal smelter in Iceland. The ENS® was designed to treat stormwater runoff from the facility to meet the Environmental Operating Permit.

Our client targeted the use of sustainable "green" technologies to lower the rates and volumes of stormwater runoff and more importantly, remove low level contaminants (i.e., suspended solids, metals and fluoride) prior to discharge to the fjord. A major objective of the project and commitment to the community was to change the facilities footprint from a typical 75% "brown" to 75% "green".

The ENS® collects stormwater runoff from production/industrial areas and provides pre-treatment via vegetated filter strips, swales and engineered soil profiles. Water is then conveyed to two Constructed Treatment Wetlands (CTWs) for detention and treatment. Each CTW includes a sediment forebay for removal of suspended solids, a series of high and low wetland marshes for contaminate removal via filtration, adsorption, and degradation, followed by an open water micropool for final polishing.

Due to the lack of plant nurseries in Iceland, the vegetated areas were seeded and planted with native vegetation collected and transplanted from farms in the surrounding region. Care was taken to ensure only native species (both plant and seed) would be utilized within the system to minimize the spread of non-natives/invasives through Iceland.

Keywords: stormwater, vegetative filter strip, metals, fluoride, treatment wetland

* Amanda Ludlow, 209 Shafter Street, Islandia, New York, 11749, 631-232-2600, aludlow@rouxinc.com

Phytoremediation of irrigation water with ***Limnocharis flava, Thalia geniculata*** and ***Typha latifolia*** in constructed wetlands

Percy Erasmus Korsah*, Coventry University; Alexander K. Anning, Ohio University; Patrick Addo-Fordjour, University of Kuala lumpur.

Phytoremediation is generally believed to be an efficient, cost-effective and sustainable wastewater treatment option for developing countries, although the technology has yet to be fully explored in these countries. The purpose of this study was to assess the potential of three aquatic plants, *Limnocharis flava*, *Thalia geniculata* and *Typha latifolia*, as phytoremediants of heavy metal contaminated irrigation water in Kumasi (Ghana) using a constructed wetland. The wetland consisted of three treatment lines each planted to one of the species. Duplicate plant and water samples were collected bi-monthly and analyzed for Fe, Cu, Zn, Pb and Hg using the AAS over a six month period. The results showed substantial accumulation of the trace metals by the plants, with Fe (~1600mg kg^{-1}) and Pb (5.71mg kg^{-1}) respectively as the most and least accumulative metals. Bioaccumulation and translocation factors varied greatly among species for different metals. *L. flava* and *T. geniculata* hyperaccumulated Hg. Removal efficiencies ranged from a mean of ~20% for Cu and Pb to ~70% for Fe, but did not differ statistically ($P >$ 0.05) among species. Our study suggests that phytoremediation with *L. flava, T. geniculata* and *T. latifolia* has potential for purification of irrigation water.

Keywords: bioaccumulation, heavy metal, Kumasi, removal efficiency, translocation

* Percy Erasmus Korsah, 43 Monks road, Coventry, CV1 2BZ, UK percykorsah@yahoo.com

QUICK TALK & POSTER PRESENTATIONS

Quick Talk & Poster Presentations

The Use of *Thypa latifolia* Plant for Fenol and Surfactant Removal in Grey Water with Subsurface Flow Contrusted Wetland System

Melati Ferianita Fachrul*, Trisakti University; Diana Hendrawan, Trisakti University

The paper reports the treatment performance capability of Subsurface Flow Contrusted Wetland (SFCW) for domectic wastewater treatment. The domestic wastewater was pumped from waste water treatment pond as primary treatment into SFCW. The main components of SFCW were substrate such as sand, soil and aquatic vegetation as *Thypa latifolia*. Wastewater containing pollutants with high concentrations after through constructed wetlands is expected to decrease its concentration. Constructed wetlands, will eliminate a wide range of materials pollutant loads. The focus of this paper is the description on the ability of plants to degrade phenol and surfactant concentration on particular domestic waste from households and offices in the city. The design used is constructed wetlands using sub surface flow. Retention time was 12 hours, 24 hours and 48 hours. The efficiency of constructed wetlands show that Phenol reduction in the retention time 12 hours was 40%, 24-hour of retention time was 54% and retention time during 48 hours was 61%. Meanwhile, the surfactant concentration during retention time 12 hours was 51%, 24-hour of retention time was 64% and 48 hours of retention time was 80%. The presence of *Thypa latifolia* in the constructed wetland contribute to the process of photosynthesis to supply the oxygen together with microorganisms as removal the concentration of domestic waste water pollutant.

Keywords: *Thypa latifolia*, Grey Water, Subsurface Constructed Wetland, Phenol, Surfactant.

* Melati Ferianita Fachrul, Jl. Tebet Timur Dalam IV L No. 4 Jakarta 12820, INDONESIA, melatif_99@yahoo.com, melati@trisakti.ac.id

Quick Talk & Poster Presentations

Where does the Elements in Benthic Plant?

Zehra Sapci*, Yildiz Technical University, Bitlis Eren University

The objectives of this experimental study were to examine where the element stay in the benthic plant body after shifting the elements from aquatic environments to the plant. Change in three element (Ca, Fe, and Mg) concentrations in *Myriophyllum verticillatum*, collected from Kucukcekmece lagoon in Turkey, was investigated in laboratory conditions. After digested the plant samples, the elemental composition of the plant was analyzed by ICP_MS. In addition, the composition of the undigested samples were investigated by the scanning electron microscopy (SEM) system equipped with Oxford INCA EDS (Energy Dispersion Spectroscopy) software. After 1060 hours experiment, the partial amount of each element was calculated to determine the order of preference among the elements. The translocation of metals both from the sediments to the roots ([metal]roots/[metal]sediments) and from water to the roots ([metal]roots/[metal]water) were calculated to find translocation factor (TF) of the benthic plant. It was found that the concentration of all of the elements in the plant was changing relatively. On the basis of the partial ratio of each element, the affinity of the plant for different elements was found to follow the order of Ca > Fe > Mg. The SEM images in the study indicated that these elements had found both the surface of the leaves and inside of the vascular tissues of the root. The results indicated that these elements can shift both from the sediment and/or the water to in the plant body and from the water to on the leaves.

Keywords: scanning electron microscopy, water, sediment, translocation factor.

* Zehra Sapci, Bitlis Eren University, Environmental Engineering Dept. Bitlis, Turkey
zsapci@beu.edu.tr

Lead Pollution and Living Bacteria Containing Fertilizers

Brigitta Tóth*, László Nagy, László Géza Nagy, Szilvia Veres, László Lévai
Department of Agricultural Botany and Crop Physiology, Institute of Crop Sciences, Faculty of Agricultural and Food Sciences and Environmental Management, Centre for Agricultural and Applied Economic Sciences, University of Debrecen

Lead (Pb) and its compounds are widely used in the industries, hence they are commonly found in air, water, soil and food. Pb is a heavy metal of great environmental concern and poses threat to plants, animals and human health due to its bio-accumulative ability and toxicity. Plants absorb Pb usually accumulating it in the roots, acting like a natural barrier. Eight Pb concentrations (0.1; 1; 5; 10; 20; 50; 100 and 200 mg kg^{-1}) were examined during our experiments. The experimental plant was maize (*Zea mays* L. cvs. PR5276). The plants were grown in climate chamber with controlled environmental conditions. Nowadays, living bacteria containing fertilizers (LBCF) are used for the renovation the environment after pollution. Three different LBCF were used in our experiments. The applied biofertilizer “A” contains *Azotobacter chrococcum* (1-2x10^9 db cm^{-3}) and *Bacillus megaterium* (1-2x10^8 db cm^{-3}). The biofertilizer „B” contains the following bacteria: *Azospirillum brasielnse, Azotobacter vinerolandii, Bacillus megaterium, Bacillus polymyxa, Pseudomonas fluorescens, Streptomyces albus*. The third („C”) one contains the following bacteria: *Azotobacter chroccoccum, Azospirillum* ssp., *Bacillus megaterium, Bacillus subtilis.*
To prove the positive effect of LBCF under Pb pollution, we measured the parameters as follows: dry matter of shoots and roots, intensity of dry matter accumulation of shoots and roots, relative chlorophyll contents (SPAD-index), contents of phyotosynthetic pigments (chlorophyll-a, b and carotenoids), uptake of elements in the roots and transferred to the shoots, pH of nutrient solution.
We found, that the applied bio-fertilizers decreased the effects of lead treatments.

Keywords: environmental pollution, element uptake, growth, maize, Pb

* Brigitta Tóth, 138 Böszörményi Street, Debrecen, Hungary btoth@agr.unideb.hu

Using CCA For The Assessment Of Vivaciousness Ability Of Viable Herbaceous Plants In Gatwala Forest Park, Pakistan

Dr. Sheikh Saeed Ahmad, Fatima Jinnah Women University

The present appraisal identified the species abundance/richness in an ordinate space in response to moisture content at Gatwala Forest park, a game reserve. The direct gradient Canonical Correspondence Analysis (CCA) was employed for this very purpose. Resultantly, Zone 1 species showed larger eigenvalues in ordinate space due to fluctuating availability of soil moisture, hence showed scattering in the graph. On the other hand the species in Zone 2 had shown their clustering in centre of the graph, which indicated the same requirements for the existed resources. However, with regard to species abundance/richness most of the viable species had shown almost same response, which signified more or less comparable prevailing conditions. The current research will lead towards better management of study area in order to conserve the natural habitat of this valuable game reserve.

Keywords: Game reserve, Canonical Correspondence Analysis, Species richness, Soil moisture

* Sheikh Saeed Ahmad, Department of Environmental Sciences, GIS / Environmental modeling Lab, Fatima Jinnah Women University, The Mall Rawalpindi, 46000 Pakistan
www.fjwu.edu.pk drsaeed@fjwu.edu.pk

Emission and Control Characteristics for Incineration of *Sedum plumbizincicola* Biomass

Daoxu Zhong, Key Laboratory of Energy Thermal Conversion and Control, Ministry of Education, School of Energy and Environment, Southeast University; Longhua Wu, Key Laboratory of Soil Environment and Pollution Remediation, Institute of Soil Science, Chinese Academy of Sciences; Zhaoping Zhong*, Key Laboratory of Energy Thermal Conversion and Control, Ministry of Education, School of Energy and Environment, Southeast University

Phytoextraction has become one of the most promising remediation techniques for heavy metal (HM) contaminated soils. However, the technique invariably produces large amounts of HM-enriched hyperaccumulators, which need further safe disposal. In this study, two different thermal treatment methods were investigated as potential options for evaporative separation of HMs from the residues. A horizontal tube furnace and a vertical entrained flow tube furnace were used for testing the disposal of grounded hyperaccumulators. The release characteristics of HMs (Cd, Cu, Pb, and Zn) into flue gas and residues were investigated for thermal treatment of the Cd and Zn hyperaccumulators *Sedum plumbizincicola*. In a horizontal tube furnace, incineration favors the volatilization of Cu and Cd in contrast to pyrolysis. The percentages of HMs in residues after incineration were lower than those after pyrolysis, especially for Cd, Pb, and Zn. In an entrained flow tube furnace, Zn concentration in flue gas increased with increasing temperature, but Cu and Cd concentration were fluctuated. Al_2O_3, CaO, and kaolin were compared as adsorbents and activated carbon was used as an end-of-pipe method for the capture of pollutants. Kaolin, the most effective of the three adsorbents, removed 91.2% of the Cd in flue gas, while 97.6% of the Cd and 99.6% of the PAHs were removed by activated carbon. Incineration may therefore be regarded as a viable option for the safe disposal of the biomass of the Zn and Cd hyperaccumulator biomass.

Key words: *Sedum plumbizincicola* biomass, incineration, heavy metals, emission and control

* Zhaoping Zhong, No. 2 Sipailou, School of Energy and Environment, Southeast University, Nanjing, China forever3159@163.com

Enhanced Phytoextraction Column Leachate Study: Sorption of EDTA and Heavy Metals from Leachate by applying raw and charred rice crop wastes

Muhammad Shafiq*, CEES PU; Anam Khalid, CEES PU; Firdaus-e-Bareen, CEES PU

The EDTA has been reported to enhance heavy metal (HM) bioavailability in contaminated soils especially that are contaminated with complex mixture of pollutants such as, tannery solid waste (TSW). However, potential risks like, groundwater pollution, poor biodegradation and phytotoxic effects may be associated with this synthetic chelate. The current study describes HM leaching tendency of EDTA from TSW amended soils. Also, analysis of the column leachate performed in terms of HM sorption before and after passing through charred- and un-charred rice straw (CRS & URS) as well as rice husk (CRH and URH), respectively. It was observed that application of EDTA increased HM bioavailability very significantly as compared to control but decreased *Tagetes erecta* biomass with high EDTA dose. At least 55 and 41 % of the EDTA and HM leached through columns during 36 hrs of column leachate, respectively. After passing this leachate through physical layers, the EDTA sorption was 38 and 13 % on CRS and URS while 26 and 9 % on CRH and URH, respectively. On quantification of HM retained on CRS and CRH with surface area analyzer, it was found that charred rice crop waste is extremely helpful in preventing leaching of HM and EDTA as compared to their relative un-charred fractions. The organic pollutants present in TSW and their role in the whole study was not considered. It is concluded that biochar of rice crop waste is par excellent choice as compared to raw application in controlling leaching of EDTA and HM during phytoextraction.

Keywords: synthetic chelate, enhanced phytoextraction, biochar, HM sorption, column leachate

* Muhammad Shafiq, College of Earth & Environmental Sciences (CEES), University of the Punjab, Lahore-54590 Pakistan shafiq.m@hotmail.com

Developing Sustainable Phytoremediation Systems for Eutrophic Waters using Free Floating Aquatic Macrophytes

Abid Ali Ansari*, Department of Biology, Faculty of Science, University of Tabuk, Kingdom of Saudi Arabia

Free floating aquatic macrophytes are highly capable for morphological and physiological adaptations to aquatic environment. They have very high potential to take up and accumulate nutrients through their root, stem and leave and can remove different ionic forms of nutrients specially Nitrogen (N) and Phosphorus (P) from aquatic ecosystems. In this experiment some free floating aquatic macrophytes viz. *Eichhornia, Lemna, Pistia, Spirodela, Wolffia* were applied for the treatment of eutrophic waters. The mono, bi, tri, tetra and penta cultures of selected plant species were grown in artificial nutrient media for 15 days in a controlled environment to develop sustainable nutrient phytoremediation systems. In monoculture system the nutrients removal potential of *Eichhornia* was found maximum removing 63% N and 55% P from eutrophic water. In diculture systems higher nutrients removal potential was shown by *Eichhornia* + *Pistia* which can remove up to 75% N and 62% P. Highest nutrient removal potential was observed in triculture systems of *Eichhornia* + *Lemna* + *Spirodela* which removes 92% N and 78% P from nutrient media. In tetraculture systems the nutrients removal potential was 88% for N and 75% for P of *Pistia* + *Eichhornia* + *Lemna* + *Spirodela*. The pentaculture (*Eichhornia* + *Lemna* + *Spirodela* + *Wolffia* + *Pistia*) system efficiently remove up to 85% Nitrogen and 81% of Phosphorus from the eutrophic water. The study indicates that under controlled conditions triculture phytoremediation system (*Eichhornia* + *Lemna* + *Spirodela)* is highly efficient and may be used for lowering high nutrient levels in eutrophic water.

Keywords: Aquatic macrophytes, Eutrophic waters, Phytoremediation

* Abid Ali Ansari, Department of Biology, Faculty of Science, University of Tabuk, Kingdom of Saudi Arabia, aansari@ut.edu.sa, aaansari40@gmail.com

Accumulation Of Aluminium (Al) And Iron (Fe) By Three Wetland Plants (*Cyperus Alternifolius*, *C.Prolifer*, And *C. Textilis)* In Hydroponic Setting.

O. Ayeni*, Cape Peninsula University of Technology; L. Kambizi, Cape Peninsula University of Technology; C. Laubscher, Cape Peninsula University of Technology; and O. Fatoki, Cape Peninsula University of Technology

Plant growth, pigment concentration and uptake of Al & Fe were determined for *Cyperus alternifolius, Cyperus prolifer*, and *Cyperus textilis* species in hydroponic setting to investigate Al & Fe stress. In this current study, Al and Fe uptake and growth responses of three species of Cyperus were investigated. The plants were grown hydroponically in Al and Fe-amended nutrients solution. Effects of both Al and Fe treatments on the changes of fresh and dry weights, leaf area, root length and shoot height were studied at (Al: 0.6, 1.8, 5.4, 10.8 and Fe: 60, 90, 120, and 180 ppm). The plant exhibited a decline in growth, chlorophyll content and carotenoids with Al and Fe, but Al was found to be more detrimental than Fe treatment in all three plants. It was discovered that fresh and dry weight of both root and shoot, shoot height, root length and leaf area were significantly reduced with increasing metal concentration and extended time of exposure. The roots were found to have more accumulation of Al and Fe. The results shows the three studied plants appeared to be good environmental candidate for phytoremediation of metal polluted soil. The concentrations of Al and Fe in the study is considerable and well within the range as found by other similar studies.

Keywords: *Cyperus alternifolius*, *C. prolifer*, *C. textilis*, heavy metal, phytoremediation and wetland plants.

* O. Ayeni, [1]Department of Environmental and Occupational studies, Faculty of Applied Sciences, Cape Peninsula University of Technology, PO Box 652, Cape Town 8000, Western Cape, South Africa, ayenio@cput.ac.za; ola2012nov@gmail.com

Treatment of phosphorus and nitrogen from domestic wastewater by *Echinodorus cordifolius* augmented with *Pseudomonas putida*

Jirawan Torit*, Division of Biotechnology, School of Bioresources and Technology, King Mongkut's University of Technology Thonburi, Bangkok, Thailand; Paitip Thiravetyan, Division of Biotechnology, School of Bioresources and Technology, King Mongkut's University of Technology Thonburi, Bangkok, Thailand

Phosphorus and nitrogen contamination in aquatic environments is a serious problem worldwide. This paper describes the study of phosphorus and nitrogen treatment in domestic wastewater by *Echinodorus cordifolius*. The result showed that *E. cordifolius* could reduce NO_3^-, NH_3^+ and phosphorus within 20 hrs. The result showed that plants could remove phosphorus from domestic wastewater by taking it up past the roots and using it for growth promotion and increasing the plant biomass. In addition, *Pseudomonus putida* was inoculated in the system containing *E. cordifolius*. The result found that *P. putida* contributed to *E. cordifolius* promotion for phosphorus removal which could reduce phosphorus within 14 hrs. The plant biomass of the system with *P. putida* increased higher than the system without *P. putida*. These studies illustrated that microorganisms contributed to the solubilization of available phosphorus which was attached to soil particles in domestic wastewater and induced plant growth promotion. The efficiency of phosphorus removal and the plant growth rate increased simultaneously in the system containing *E. cordifolius* augmented with *P. putida*, which proved to be a sustainable system for the treatment of domestic wastewater.

Keywords: phosphorus and nitrogen removal, domestic wastewater, *Echinodorus cordifolius* L., *Pseudomonas putida*, plant growth promotion

* Jirawan Torit, 49 Soi Thian Thale 25, Bang Khun Thian Chai Thale Road, Thakham, Bang Khun Thian, Bangkok 10150, THAILAND, Jirawan_Tiw@hotmail.com

POSTER PRESENTATIONS

1A

Bhawana, P

Rhizosphere Bioremediation of Methyl orange in Ecological Remediation Unit

Jyoti Fulekar, Central University of Gujarat; Bhawana P.*, Central University of Gujarat; M. H. Fulekar, Central University of Gujarat

The research study has been carried out for Rhizosphere bioremediation of Dye compound-methyl orange in designed and developed Ecological Remediation Unit. The Rhizosphere bioremediation of methyl orange was studied at a concentration of 25 ppm and 50 ppm over a period of 30, 45, 60 and 75 days till the bioremediation was completed. Bioengineering - rhizosphere bioremediation at a concentration of 25 ppm, 50 ppm, and 100 ppm over a period of 30, 45, 60, 75 days was also studied using indigenous microorganism as a biomass. The bioengineering of rhizosphere bioremediation was found effective as compared to rhizosphere bioremediation of methyl orange studied at a concentration of 25ppm, 50ppm and 100 ppm during the period of bioremediation in Ecological Remediation Unit.

The mycorrhizosphere having the microorganisms such as bacteria *Bacillus spp., Pseudomonas spp., Sarciana spp.,Serratia spp., Streptococcus spp*; fungi *Asergillus flavus, A. fumigatus, A. nige Penicillium spp, Rhizopus spp., Mucor spp*. and actinomycetes: *Micromonospora spp.Nocardia spp* along root zone were found effective for Rhizosphere bioremediation. The microbial consortium adapted in contaminated site of dye stuff industry was cultured and used as a microbial consortium for bioengineering rhizosphere bioremediation in ecological remediation unit; has further enhanced the Rhizosphere bioremediation. The rhizosphere bioremediation technique developed using designed and developed ecological remediation unit would be applicable from lab to land for remediation of persisting dye compound including xenobiotics in soil -water environment.

* Bhawana P., Central University of Gujarat, Sector-30, Gandhinagar, 382030
bhawanasp@hotmail.com

2A

Fulekar, M. H.

Phytoremediation of Heavy Metals and Enzymatic Mechanism in Mycorrhizosphere

Fulekar, M. H.*, Central University of Gujarat; Bhawana P., Central University of Gujarat; Anamika S., University of Mumbai

In India the nuclear industry is a fastest growing energy sector which contributes 2% production of renewable energy at present. The nuclear industry involves the handling and uses of radioactive materials. Nuclear wastes generated through chemical processing and/or nuclear weapons program have also enhanced the level of hazardous environmental contaminants. In low level nuclear wastes, concentration involved are low and volumes are large. Hence, physical and chemical methods may not be effective practice to decontaminate the low level nuclear waste. The organic as well as inorganic chemicals present in the nuclear wastes find their way in soil and water causing environmental pollution. In present research study, the mycorrhiza soil has been developed using pot culture technique in green house. The mycorrhiza soil characterization was done for physico-chemical and microbial parameters. The heavy metals such as Cu, Pb and Zn toxicity in mycorrhiza soil at a concentration viz. 0, 5, 10, 20, 50, 75 and 100 ppm was assessed using the green plants such as *Medicago sativa, Brassica juncea* and Alfalfa. These green plants have been used for phytoremediation of heavy metals at a varying concentration of 0, 5, 10, 20 and 50 ppm using the pot culture technique. The chlorophyll content and caretenoid as an indicator of plant growth and the enzymatic activities have been assessed as a defence mechanism during phytoremediation of heavy metals by these green plants. The mycorrhiza soil has been found as an effective and efficient natural fertilizer to remediate heavy metals by green plants. Phytoremediation of heavy metals in mycorrhizosphere has proved that it is an effective, efficient, ecofriendly, low cost, sustainable green technology for restoration of ecosystem in radionuclides – heavy metal polluted environment.

Keywords: Heavy metals, Mycorrhizosphere, phytoremediation, enzymatic mechanism

* Fulekar, M. H., School of Environment and Sustainable Development, Central University of Gujarat, Sector-30, Gandhinagar, 382030 mhfulekar@yahoo.com

3A

Guo, Bin

Cadmium Stabilization with Nursery Stocks Through Transplantation: A New Approach to Phytoremediation

Bin Guo*, Zhejiang Academy of Agricultural Sciences; Yongchao Liang, Zhejiang Academy of Agricultural Sciences; Qinglin Fu, Zhejiang Academy of Agricultural Sciences; Nengfei Ding, Zhejiang Academy of Agricultural Sciences; Chen Liu, Zhejiang Academy of Agricultural Sciences; Yicheng Lin,Zhejiang Academy of Agricultural Sciences; Hua Li, Zhejiang Academy of Agricultural Sciences; Ningyu Li, Zhejiang Academy of Agricultural Sciences

Disposal of heavy metal contaminated biomass after phytoremediation is still unfeasible. This paper presents a viable phyto-extraction approach in which metals in contaminated soils are stabilized by nursery stocks before transplantation for greening. In this respect, two pot-experiments are reported comparing seven nursery stocks species exposed to different Cd levels. The first experiment revealed that Cd was mainly stabilized in the roots of all species studied. Greater amounts of Cd were accumulated in the epidermis than cortex plus stele. *Cupressus Blue Ice* showed greatest tolerance to the 100 and 200 mg kg^{-1} Cd stresses. The second experiment additionally evaluated the possible risk of Cd release after transplanting the Cd treated plants into uncontaminated soil. After 120 days of transplantation, the relatively trace amounts of Cd in the roots of *Euonymus Japonicus*, *Pittosporum Tobira* and *Cupressus Blue Ice* had either been partially transferred into the shoots or released into the soil. The highest Cd concentration increase in bulk soil (0.428 mg kg^{-1}), however, was much lower than the environmental quality standard for soils of China (1 mg kg^{-1}). The potential effectiveness of this technique in the use of Cd-contaminated soil and further investigation needed in the field trials is also evaluated.

Keywords: cadmium; cortex plus stele; nursery stock; stabilization; transplantation

* Bin Guo, Institute of Environment, Resource, Soil and Fertilizer, Zhejiang Academy of Agricultural Sciences, Hangzhou, China ndgb@163.com Fax: +86 571 8640 4041

4A

Liang, Hong

Soil reclamation Based on phytoremediation at rare earth mine site

Hong Liang*, Zhongkai University of Agriculture and Engineering; Wen Liu, Zhongkai University of Agriculture and Engineering; Shenghong Liu, Zhongkai University of Agriculture and Engineering; Zhaolong Li, Zhongkai University of Agriculture and Engineering; Lingyan Zhou, Zhongkai University of Agriculture and Engineering; Anqiang Dong, Zhongkai University of Agriculture and Engineering

Overexploitation of rare earth mine land causes desertification and various environmental problems including land aridity, water and soil erosion, headwater pollution, and downstream cultivated land damage. Phytoremediation is an emerging technology that uses various plants to recover the vegetation at rare earth wasteland. To find effective methods to restore the eco-system andagricultural productivity in a rare earth mining area, the mined land was filled with organics and phytoremediation experiments were carried out. Soil bacterial biomass, soil fertility and the vegetation were studied in the course of phytoremediation at the rare earth mine sites in Heping County and Pingyuan County, Guangdong Province, P. R. China. The results showed that the phytoremediation could markedly improve the soil physicochemical properties, raise soil fertility and increasesoil bacterial DNA polymorphism. The artificial vegetation could stably growth at the restored rare earth mine sites. The selected crops such as corn, alfalfa, *Stylosanthes scabra* and so on, could be cultivated in the restored soil. Ecological restoration of the rare earth mining area could be estimated through quantity difference and polymorphism analysis of the soil bacteria, change of the soil fertility and growth of the cultivated plants at the rare earth mine land.

Keywords: soil reclamation, phytoremediation, rare earth mine site

* Hong Liang, College of Life Sciences, Zhongkai University of Agriculture and Engineering, Guangzhou 510225, P. R. China. lhofice@yahoo.com.cn

5A

Wang, Zhaolong

A comparison study in cadmium phytoremediation capacity between two turfgrasses and *Solanum nigrum* L.

Peixian Xu, Shanghai Jiaotong University; Zhaolong Wang*, Shanghai Jiaotong University

A pot culture study was designed to compare the capacity of Cd tolerance and accumulation between two cool-season turfgrasses (*Poa pratensis* L. and *Festuca arundinacea* Schreb.) and a Cd hyperaccumulator(*Solanum nigrum* L.) under the Cd stresses (40 and 80 mg Cd kg^{-1}) for 9 weeks. Two turfgrasses did not show any Cd toxic symptom, but the necrotic spots and whitish-brown chlorosis were observed in the old leaves of *Solanum nigrum* inboth Cd treatments. Both shoot and root biomass in *Solanum nigrum* were decreased significantly under both Cd treatments to 55.5% and 35.7% (40 mg Cd kg^{-1}) and 50.9% and 22.8% (80 mg Cd kg^{-1}) of the control, respectively. Both shoot and root biomass in two turfgrasses did not show significant decline under the 40 mg Cd kg^{-1} treatment, but under the 80 mg Cd kg^{-1} treatment, they were decreased to 95.3% and 77.6% (*Festuca arundinacea*) and 94.1% and 71.4% (*Poa pratensis*), respectively. The amount of Cd accumulation in plants increased with the increase of Cd concentration treatment in all three species. *Solanum nigrum* accumulated 9.4 mg Cd/m^2 under 40 mg Cd kg^{-1} treatment and 63.7 mg Cd/m^2 under 80 mg Cd kg^{-1} treatment. Shoot of *Solanum nigrum* accumulated 90.4% (40 mg Cd kg^{-1} treatment) and 94.3% (80 mg Cd kg^{-1} treatment) of the total cadmium. *Festuca arundinacea*accumulated 383.4 mg Cd/m^2 under 40 mg Cd kg^{-1} treatment and 761.5 mg Cd/m^2 under 80 mg Cd kg^{-1} treatment, which were about 40 and 12 fold of *Solanum nigrum*, but the shoot only accumulated 12.8% (40 mg Cd kg^{-1} treatment) and 25.4% (80 mg Cd kg^{-1} treatment) of the total cadmium. *Poa pratensis*accumulated 418.6 mg Cd/m^2 under 40 mg Cd kg^{-1} treatment and 1114.9 mg Cd/m^2 under 80 mg Cd kg^{-1} treatment, which were about 51 and 17 fold of *Solanum nigrum*, with 34.7% (40 mg Cd kg^{-1} treatment) and 57.6% (80 mg Cd kg^{-1} treatment) of the total cadmium accumulated in the shoot. The results indicated that *Poa pratensis* and *Festuca arundinacea* might be the better candidate plants for phytoremediation purpose in Cd contaminated soil than *Solanum nigrum.*

Keywords: cadmium phytoremediation, *Poa pratensis*, *Festuca arundinace*, *Solanum nigrum.*

* Zhaolong Wang, 800 Dongchuan Road, Shanghai, P.R. China turf@sjtu.edu.cn

6A

Chattopadhyay, Amitabha

Interspecies variation between Lemongrass and Palmarosa on their Root Binding Capacity for Nickel, Cadmium and Chromium in soil

Amitabha Chattopadhyay*, CSIR

Lemongrass (*Cymbopogon flexuosus*) and Palmarosa (*Cymbopogon martinii)* are the two essential oil bearing grasses of genus cymbopogon (poaceae family). The essential oil of these grasses is the natural sources of citral ex lemongrass and geraniol ex palmarosa along with other terpenoids compounds. The advantage of growing these grasses in metal contaminated lands is that these grasses are not edible and the essential oil is extracted only through steam distillation of the herbage. Thereby possibility of metal contamination in the distillate oil would be less.

The experiments were carried out at the institute to assess the heavy metal tolerance of Lemongrass and Palmarosa in alluvial soil spiked with graded levels of Ni (0-400 ppm) Cd (0-200 ppm) and Cr(0-200 ppm). The results revealed that both the grasses thrive well with varying level of tolerance for Ni, Cd and Cr in soil without affecting the oil yield and the chemical composition of their essential oil. The Ni, Cd and Cr concentration in roots of the grasses increased with increased level of metal application and it was much more than that in the shoot tissues of the respective plant. Lemongrass has the capacity to bind more Ni, Cd and Cr per unit level in their roots as compared to Palmarosa.

This open up the possibility of growing Lemongrass and Palmarosa in heavy metal contaminated soil where these grasses will act as phytostabelizer by binding the heavy metals in their roots and restricting their upward movement to the shoot tissues.

Keywords: Heavy metal, Lemongrass, Palmarosa, Cymbopogon, Remediation

* Amitabha Chattopadhyay, Division of Agronomy and Soil science, Central Institute of Medicinal and Aromatic Plants (CSIR), PO:CIMAP, Lucknow-226016, Uttar Pradesh, India
amitabha_54@yahoo.com; a.chattopadhyay@cimap.res.in

7A

Angelova, Violina

Potential of Rapeseed *(Brassica napusoleifera biennis)* for Phytoremediationof Soils Contaminated With Heavy Metals

Violina Angelova*, University of Agriculture,Vanja Akova, University of Agriculture, Galina Uzunova, University of Food Technology, Mariana Perifanova Nemska, University of Food Technology

A field study was conducted to evaluate the efficacy of rapeseed plant for phytoremediation of contaminated soils in the absence and presence of organic soil amendments (compost and vermicompost, added at 5 and 10%). The contents of heavy metals (Pb, Zn and Cd) in the plant material (roots, stems, leaves and seeds) and in the oils and meals of rapeseed were determined by ICP. Fatty acid composition was established by gas liquid chromatography.
The application of soil amendments favours plant growth and development.Organic amendment application led to an effective immobilization of Pb, Zn and Cd mobile forms in soil. A correlation was found among the quantity of the mobile forms and the uptake of Pb, Zn and Cd by the seeds. Oil content and fatty acids composition were affected by compost and vermicompost amendment treatments. Tested organic amendments increased linoleic acid and palmitic acid, and decreased oleic acid in rapeseed oil.
The compost and vermicompost treatments significantly reduced heavy metals concentration in the seeds, meals and oils, but the effect differed among them. Also, there was a dose effect for amendments. The 10% compost and 10% vermicompost treatment led to decreased heavy metal contents in rapeseed oil bellow the regulated limits. The possibility of further industrial processing will make rapeseed economically interesting crops for farmers of phytoremediation technology.

Keywords: rapeseed, heavy metals, organic amendments, contaminated soils

* Violina Angelova, University of Agriculture, Plovdiv, Bulgaria vileriz@yahoo.com

8A

Ramprakash

Phytoextraction of Lead from Pb Contaminated Soil by *Zea mays* as Influenced by chelating agents

Ramprakash*, CCS Haryana Agricultural University; Anoop Singh, CCS Haryana Agricultural University

Chemically enhanced phytoextraction has been proposed as an effective approach to removing heavy metals from contaminated soil through the use of high biomass plants. For this a pot experiment was conducted to evaluate the effect of Chelating agent on phytoextraction of Pb by using Chelating agent i.eCyclohexanediaminotetraacetic acid (CDTA), Citric acid (CA), Diethylenetriaminepentaacetic acid (DTPA), Nitrilotriacetic acid (NTA) @ 10 mmol kg^{-1} soil 40day after sowing and FYM (at 3%) with in Zea mays the sewage sludge unamended and amended (at 3%) soil. Application of chelating agents influenced dry matter yield and uptake of Pb by roots and shoots differentially depending upon the nature of the chelating agents. Application of chelating agents decreased the dry matter yield of roots of Zea mays while, higher values of Dry Matter yield (8.86 g $pot^{-1)}$ was observed in case of FYM sewage sludge amended soil at 80 Days after sowing. FYM addition was found beneficial as compared to control (Pb_{180}). Dry matter yield of shoots of Zea mays increased over control due to application of CDTA and FYM. The highest value of dry matter yield of shoot (63.29 g $pot^{-1)}$ was observed in case of CDTA with sewage sludge amended soil at 80 Days after sowing. Whereas reverse trend was observed in NTA, CA and DTPA treated soils. Addition of sewage sludge at 3% on dry weight basis was found beneficial in improving the plant growth. Chelating agents enhanced the Pb uptake by both roots and shoots, higher values of Pb uptake by roots (2888.19 µg pot^{-1}) and shoots (13212.07 µg pot^{-1}) Was observed in CDTA treated soil after 80 days of sowing in amended as compared to sewage sludge unamended soil. Application of CDTA was found more effective in enhancing the Pb uptake by Zea mays roots and shoots than any other chelating agents at both the growth stages. The chelating agents are found useful in enhancing phytoextractability of Pb by Zea mays. Hence, marginally Pb contaminated soil may be remediated by adding chelating agents.

* Ramprakash, Department of Soil Science, CCS Haryana Agricultural University,Hisar,125004, India ramsansanwal@gmail.com

9A

Alessandro, Mattiello

Are the reducing sugars the driving force for Ag nanoparticles biosynthesis in living plants?

Alessandro Mattiello*, UNIUD; Rita Musetti, UNIUD; Filip Pošćić, UNIUD; Guido Fellet, UNIUD; Luca Marchiol, UNIUD

The NPs biosynthesis in living plants is still a poorly known process. The driving force of such process inside the plant tissues is the redox potential that the plant can put at play. It is likely that the source of redox potential derives primarily by reducing sugars (glucose and fructose). With the aim to verify this hypothesis a set of experiments is currently running. Seedlings of, *Brassica carinata* cv. L194525, *Brassica juncea* cv. Vittasso, *Cucurbita pepo* cv. *Di Faenza*, *Festuca rubra Medicago sativa* cv. Robot, *Sorghum bicolor* cv. Cheope, *Zea mays* cv. Sintesis, previously germinated, are raised in hydroponic culture (Hoagland) for a growth cycle of about 30 d. At the end of the cycle in a subset of plants the concentration of reducing sugars in young leaves are determined. Some other plants are hydroponically treated with a solution of $AgNO_3$ (100 ppm). Samples of tissue are collected after 24 h on the root, collar, stem (internode) and on the leaf blade near the main vascular system. Plant tissues are observed using the TEM technique to localize the NP; the tissue element concentration is determined using an ICP-OES. The dimensional characterization of the AgNPs within the plant tissue is carried out by means of an SEM-EDX.
The expected results will allow verifying the relationship, if any, between the concentration of reducing sugars and the amount/size of nanoparticles synthesized by plants.

Keywords: Biosynthesis, Silver nanoparticles, plants, reducing sugars

* Alessandro Mattiello, Department of Agriculture and Environmental Sciences, University of Udine Via delle Scienze 206, 33100 Udine (Italy), alessandro.mattiello@uniud.it

10A

Gerth, André

Recultivation of mining areas and treatment of acid mine water using Constructed Wetland

André Gerth*, Vita 34 AG; Stefan Klotz, UFZ – Helmholtz-Centre for Environmental Research; Sonja Knapp,UFZ – Helmholtz-Centre for Environmental Research

A German -Vietnamese R&D project on recultivation of rock dumps in coal mining areas has been carried out. Recultivation should decrease erosion intensity, dust emission rates, water pollution, and activate soil development. Vita 34 tested plant species being native to Vietnam and allowing post-mining land use. Planting strategies were developed which do not require covering the whole waste rock dump area but establishing a net of 'vegetation islands'. A reduction of the necessary planting material lowers recultivation costs. For initial plantations, Vita 34 suggests planting species along the edges of waste rock dump plateaus. These edge plantations should surround several plant groups planted on the plateau. For establishing vegetation islands on slopes, it is advantageous if the slope has benches that can be planted. In addition to field studies, Vita 34 tested *in vitro* propagation at the German laboratories for determining the most efficient possibilities of providing sufficient amounts of plants for recultivation.

From waste rock dumps acidic mine waters are leaching. These acidic waters transport heavy metals in dissolved form, bound to particles or suspended in water, for example manganese. Based on laboratory tests a Constructed Wetland was built for the immobilisation of heavy metals and the neutralisation of pH-value. The technology tested on a pilot scale takes advantage of biological, physical, and chemical processes to purify water, and it does not depend on power supply. Water treatment using Constructed Wetland decreased all relevant parameters below the critical thresholds (TCVN 5942-1995).

Keywords: rock dumps, recultivation, mine rehabilitation, post-mining land use, vegetation cap

* André Gerth, Deutscher Platz 5a, 04103 Leipzig, Germany, info@vita34.de

11A

Oke, Olajide

Soil Seedbank dynamics and regeneration in three different Physiognomies in Shasha Forest Reserve in southwestern Nigeria

Olajide Oke*, Obafemi Awolowo University; Damilare Akinyemi, Obafemi Awolowo University

Seed bank dynamics and forest regeneration of disturbed Shasha forest reserve in Southwestern Nigeria were studied with a view to determining the potential contribution of the soil seed bank to the restoration of the degraded forest reserve. Two plots 25 m x 25 m were selected in each of the three distinct sites (*Taungya* system, Natural regrowth forest and *Gmelina arborea* plantation) and all the plants of the standing vegetation were enumerated and identified to species level. Five replicates soil samples were collected at two different depths (0-15 cm and 15-30 cm) from each plot in dry and rainy season. The soil samples were subjected to seedling emergence for six months to determine the density and species composition of the three study sites. The results of seedling emergence showed that soil collected at 0-15 cm depth had a higher seed density than soil collected at 15 -30 cm depth in both seasons. Few woody species emerged from the soil seed bank and herbaceous species dominated the emerged species in the three study sites and in the two seasons. Site A (*Taungya* system) had significantly higher ($P < 0.01$) seed density than the other two sites. There was low similarity (4.44%-11.76%) in species composition between the standing vegetation and the soil seedbank. The standing vegetation was poorly represented in the soil seed bank but it was better in Site C (*Gmelina arborea* plantation). The potential for vegetation restoration of the degraded forest reserve from the soil seed bank is insignificant.

Keywords: Seed bank, restoration, forest reserve, *Taungya* system, Shasha, depths

* Olajide Oke, Department of Botany,Obafemi Awolowo University, Ile-Ife, Nigeria.soke@oauife.edu.ng

12A

Rodriguez, Mariana

**Native versus exotic invasive plant species in constructed wetlands:
The case of common reed in North America**

Rodriguez Mariana*, Université de Montréal; Brisson Jacques, Université de Montréal

Because of its long proven ability in water treatment, the common reed (*Phragmites australis)* is the most widely used plant species in constructed wetlands (CWs) around the world. At the same time, however, there are growing concerns over its use because it is considered highly invasive. In Quebec (Canada), for instance, CW designers previously using phragmites are now forced to find an alternative native species for their CWs.

In North America, a native noninvasive subspecies of common reed was recently identified. In the context of a search for alternatives to the use of invasive species, we compared the removal efficiency between the native and invasive phragmites in a mesocosm experiment.

We found no evidence that invasive phragmites outperforms the native one in CWs. Both subspecies showed excellent removal efficiencies and there was no difference in average removal for any of the pollutants measured, except for phosphate removal, which was actually higher in the native phragmites. These results are surprising since we expected that the larger growth and superior ecophysiological characteristics documented for the invasive subspecies under natural conditions would have resulted in a more efficient pollutant removal.

Our results suggest that native phragmites could be used as an alternative to the invasive subspecies in North America. However, while removal efficiency is the most important factor in choosing a plant species for CWs, other characteristics cannot be neglected. This is particularly the case for their resistance to diseases, since native plants are assumed to be more susceptible than exotic species.

Keywords: wastewater treatment, macrophytes, Phragmites, constructed wetlands, pollutant removal

* Rodriguez Mariana, 4101 Sherbrooke Est, Montréal, Québec H1X 2B2
mariana.rodriguez@umontreal.ca

13A

Darlington, Alan

VOC Removal Kinetics of Planted Biofilters

Alan Darlington*, Nedlaw Living Walls; David Llewellyn, University of Guelph; Michael Dixon, University of Guelph

Indoor air biofilters are a hybridization of phytoremediation and biofiltration. Air from an occupied space is actively drawn through a vertical hydroponic substrate where beneficial microbes degrade airborne volatile organic compounds (VOCs). Green plants are integrated into the biofilter to induce greater microbial activity. Three biofilters were tested under controlled laboratory conditions. The biofilters were planted with a range of interior foliage plants and subjected to synthetic 'dirty air', containing methyethylketone (MEK), trichloroethylene (TCE) and toluene. Ambient VOC concentrations in the space (the influent) and the effluent air from the biofilters were monitored by an automated gas chromatogram (GC). The GC was interfaced with a peripheral VOC release system which passed a metered amount of air through a VOC filled impinger and released into the space to get the desired VOC profiles. The contaminants cycled between roughly 25 to 100 ppbv on a daily basis.

The biofilters demonstrated rapid acclimation to toluene and MEK with substantial removal within hours of their first exposure to the contaminants. Stable removals of approximately 60% were obtained after 7 days of exposure. Earlier work indicated the performance of similar biofilters could be summarized with a simple linear relationship between influent and effluent concentrations to give a single removal efficiency that was consistent over the range of influents. However the current study suggests that logarithmic or exponential models better describes the relationship. This new model also held true when the daily influent cycled was between 100 and roughly 600 ppbv.

Keywords: indoor air quality, biofiltration, VOCs, phytoremediation, BTEX

* Alan Darlington, 250-1 Woolwich St S, Breslau, ON, Canada N0B 1M0 alan@nedlaw.ca

14A

Islam, Md. Monirul

Phytoremediation of copper contaminated soils by tropical timber tree species

M.M. Islam*, Bangladesh Agricultural Research Institute; Nik M. Majid, University Putra Malaysia; M. Ghafoori, University Putra Malaysia

Heavy metals are being transported and mixed with the cultivated soils and water. High concentrations of heavy metals are harmful to plants, animals and humans and their potential accumulation in human tissues and bio-magnification through the food chain cause serious health hazards. These soil contaminants need to be cleaned up for safety environment. An experiment was conducted to evaluate the potential of *Jatropha curcas*, *Acacia mangium* and *Hopea odorata* as phytoremediators capable of absorbing copper (Cu) from sewage sludge contaminated soils. Seedlings were planted on six different growth media (soil + sludge) as follows: T0 (100% soil), T1 (80% soil+20% sludge), T2 (60% soil+40% sludge), T3 (40% soil+60% sludge), T4 (20% soil+80% sludge) and T5 (100% sludge). The highest growth performance for height and biomass was in 100% sludge. The highest Cu accumulation was recorded in 100% sewage sludge. Among the plant parts, roots contained the highest Cu concentration and among the three species it was highest in *J. curcas.A. mangium* and *H. odorata* showed the highest biconcentration factor (BCF) in the control treatment while *J. curcas* had the highest BCF in T1. The highest translocation factor for *J. curcas* and *A. mangium* was in T5 whereas T2 showed the highest translocation factor for *H. odorata*. *J. curcas* and *A. mangium* had high translocation factor (TF) and low BCF in the soil with higher Cu concentrations. Therefore, *J. curcas* and *A. mangium* can be used to decontaminate Cu polluted soil.

Keywords: Tropical tree species, heavy metal contamination, phytoremediation, sewage sludge, translocation

* M.M. Islam, Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh monirupm.my@gmail.com Tel: +88-01552329093

15A

Raimi, Idris

A comparison between the crude oil-remediating potentials of Cynodon dactylon L. and Eleusine indica L. (Gaertn)

Idris Olawale Raimi*, Obafemi Awolowo University; Anthony Odiwe, Obafemi Awolowo University; Stephen Oyedeji, University of Ilorin

The study compared the remediating potentials of *Cynodon dactylon* L. and *Eleusine indica* L. (Gaertn.) at the greenhouse, Faculty of Agriculture, Obafemi Awolowo University, Nigeria using crude oil as contaminants. Crude oil of known concentration was applied at the rate of 0.0, 2.5, 5.0, 7.5, 10.0 and 12.5 ml/bowl to 3 kg soil in three replicates per treatment for each grass species planted in a complete randomized block design. Soil physicochemical properties were determined at the beginning and end of the study. Fresh and dry weight of the plants was measured 12 weeks after planting. The total hydrocarbon content (THC) in soil and plant after harvest was determined. Student's t-test used compared measures between the two species while ANOVA and Duncan Multiple Range Test were used to separate means within each grass species at 5% probability. Soil pH and organic carbon content for C. dactylon and E. indica were not significantly different ($p \geq 0.05$) except in the 2.5 ml treatment. Fresh and dry weights were significantly higher in E. indica in all treatments ($p > 0.05$) except in the control and 2.5 ml treatments. In all treatments, no residual crude oil (THC) remained in the soil, but residual THC in the tissues of C. dactylon was significantly higher than that of E. indica except in the 2.5 ml and 5.0 ml treatments. It was concluded that E. Indica was a better remediating plant than C. dactylon due to lower THC in its tissues.

Keywords: crude oil, Cynodon dactylon, Eleusine indica, hydrocarbon, potential.

* Idris Olawale Raimi, Institute of Ecology and Environmental Studies, Obafemi Awolowo University, 220005, Ile-Ife, Nigeria, rimiidris@yahoo.com

16A

Mangu, Soumya

Effect of functionalization and morphology on the toxicity of carbon nanomaterials to agricultural crops

Soumya Mangu*, University Of New Haven; Jason C. White, Connecticut Agricultural Experiment Station; Saion Sinha, University Of New Haven; Joe Hawthrone, Connecticut Agricultural Experiment Station; Roberto De La Torre-Roche, Connecticut Agricultural Experiment Station; Lakshmi Namagiri, University Of New Haven

The increasing use of different kinds of nanomaterials in industrial and agricultural sectors has raised considerable environmental, health and safety concerns. As studies exploring potential toxicity of nanomaterials to food crops are scarce, herein we report on the developmental responses of agriculturally significant plants (zucchini, soybean, lettuce, spinach, alfalfa) upon exposure to non-functionalized and functionalized (OH-, COOH-, and NH_2-) multi-walled carbon nanotubes (MWCNT) and graphene sheets. The impact of 7-d exposure (1000 mg/L) in the presence or absence of humic or fulvic acid on germination rate and seedling growth under hydroponic conditions was evaluated. In addition, nanomaterial size was measured by atomic force microscopy (AFM) and by dynamic light scattering (Zeta sizer). In the absence of humic or fulvic acid, MWCNT exposure had no impact on zucchini germination but non-functionalized, as well as –COOH and –NH_2 functionalized MWCNT, significantly increased the biomass of germinated soybean seedlings. However, in the presence of 100 mg/L humic acid, COOH and –NH_2 functionalized MWCNTsignificantly decreased soybean germination rates but this toxicity disappeared at 50 mg/L humic acid. Soybean germination was significantly increased by COOH-functionalized MWCNTin the presence of 100 mg/L fulvic acid. Graphene nanoplatelets at 1000 mg/L decreased the biomass of germinated lettuce, alfalfa, spinach and soybean seedlings. Current investigations are focusing on the effects of carbon nanomaterial exposure under 10-day hydroponic exposures on crop biomass and transpiration. The findings of this study have implications for the accurate exposure and risk assessment of nanomaterial use in agricultural systems.

Keywords: Nanotoxicology, Carbon nanomaterials, Phytotoxicity

* Soumya Mangu, Dept. of Physics, University Of New Haven, West Haven, CT-06516, mangurinda@gmail.com

17A

Falodun, Dare

Effects Of A Mixture Of Spent Engine Oil, Diesel And Gasoline On Nerica Rice (Tox, Mecux & Wita.4) Agronomic Parameters

Dare Falodun*, University of Lagos; Kelechi Njoku, University of Lagos, Modupe Akinola, University of Lagos

This study investigated the tolerance level of three NERICA (New Rice for Africa) rice varieties (MECUX, TOX and WITA.4) grown in a mixture of spent engine oil, fresh diesel fuel and gasoline contaminated soil. The concentrations of the pollutant mixture used were 1%, 2%, 3%, 4% and 5% (w/w). The results showed that percentage germination decreased significantly in MECUX and WITA.4 varieties ($P < 0.01$) while germination in TOX seedlings were not significantly affected ($P > 0.05$). None of the treatments adversely affected percentage survival of the three rice varieties ($P > 0.05$) except MECUX variety which was significantly reduced by 4% concentration of the pollutant mixture ($P < 0.05$). Statistical analysis shows that no significant reduction was observed in main – culm leaf number of the three NERICA rice varieties ($P > 0.05$). Although, the number of tillers and number of productive tillers of the plants were reduced at 3 – 5% concentrations ($P < 0.05$, $P < 0.01$ and $P < 0.001$), except Tox variety ($P > 0.05$). The results indicated that percentage tillering efficiency of the three NERICA rice varieties was unaffected by the pollutant ($P > 0.05$). However, 2 – 5% concentrations of the pollutant mixtures significantly reduced the rate of panicle extrusion and panicle weight ($P < 0.05$, $P < 0.01$ and $P < 0.001$), while panicle length and panicle number were unaffected ($P> 0.05$). The results of this study suggest that knowledge of stress and disturbance physiology can contribute to rice production programmes in oil polluted environments.

Keywords: rice, tillers, panicle, germination, NERICA rice.

* Dare Falodun, University of Lagos, Akoka Lagos Nigeria, falodundare@gmail.com

18A

Zacchini, Massimo

Metal phytoremoval ability in *Amaranthus paniculatus* L.: a biometric, physiological and biochemical study in plants treated with Ni under hydroponics

Fabrizio Pietrini, IBAF-CNR; Valentina Iori, IBAF-CNR; Alexandra Cheremisina,IPP-RAS; Nina I. Shevyakova IPP-RAS; Nataliya Radyukina IPP-RAS; Vladimir V. Kuznetsov, IPP-RAS; Massimo Zacchini*, IBAF-CNR

Recent studies on the risk assessment of wastewaters highlighted Ni as one of the chemicals of greatest concern for the environment. In fact, even though this metal is a natural constituent of igneous rocks, its diffusion in the environment has remarkably increased in the last decades because of the industrialisation processes at global scale. Ni is an essential micronutrient for living organism but its excessive level in the environment represents a serious threat for the food chain and the ecosystem survival. To reduce the metal contamination of soil and water, a sustainable technology such as phytoremediation has been receiving increasing attention. The selection of specific plant species able to tolerate, remove and accumulate metals in the harvestable plant parts is a crucial step for a wider and successful application of this technology. For this purpose, hydroponic experiments aimed at investigating biometric, physiological and biochemical parameters characterising the growth and the metal accumulation pattern in metal-exposed plants were commonly reported in the literature. In this study, we focused our attention on *Amaranthus paniculatus* L., a non Ni-hyperaccumulating plant species, as it was reported to produce high biomass and accumulate large amounts of metals in metal-contaminated sites in Russia. An experimental trial targeted to assess the Ni phytorememediation properties of this plant species under hydroponics was then conducted. Results showed a good adaptation of *Amaranthus paniculatus* L. plants to liquid medium culture and a notable Ni tolerance and phytoremoval ability especially at environmentally relevant metal concentrations.

Keywords: heavy metals, metal tolerance, metal accumulation, phytoextraction, phytoremediation

* Massimo Zacchini, Institute of Agro-environmental and Forest Biology, National Research Council of Italy, Via Salaria Km 29,300, 00015 Monterotondo Scalo (Roma), Italy, massimo.zacchini@ibaf.cnr.it

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Han, Gwang Hyun

Assessment of Heavy Metals Incorporated into Soil Microbial Biomass with a Direction Chloroform Extraction Method

Jongchan Park, Seokho Jung, Hyunjae Kwon, Chowon Kim, Bomin Kang, Eunjin Lee, Gwang Hyun Han*, Chungbuk Natl. Univ.; Dongwook Kim, Phygen Inc.

For assessing bioavailability of heavy metals, total metal content is often partitioned into labile, directly available, and inert fractions. On the other hand, soil microorganisms not only uptake macronutrients (C, N, and P), but also micronutrients and heavy metals. However, the role of soil microorganisms in turnover and storage of heavy metals has not been investigated enough, mainly due to difficulties in direct extraction of that fraction. In assessment of microbial C and N, the chloroform fumigation and extraction method is widely used, based on the fact that cell lysis caused by fumigation increases extractable organic C relative to a nonfumigated control. We have used a similar approach but with a slight modification to quantify heavy metal contents in soil microbial biomass. Direct chloroform extraction rather than fumigation was tried, because various gas permeability of the soil can give inconsistent fumigation efficiency. In addition, 0.5 M $MgCl_2$ was used as the extractant to minimize spectral interferences. For a heavy metal contaminated rice paddy in southern Korea, the amounts of microbial (or chloroform-extractable) fraction are estimated to be around 3% and 9% of the total for Cd, and Ni, respectively. However, the microbial fractions of Cu, Pb, Zn, and As were very small (<1%). There was no significant relationship among the different fractions of heavy metals. In general, in comparison with water-soluble (0.1-2%) and labile (2-40%) pools, the microbial fraction was considered to be an important factor determining bioavailability of heavy metals, depending on soil characteristics and contamination pattern.

Keywords: Phytoremediation, Bioavailability, Fractionation, Immobilization, Turnover

* Gwang Hyun Han, Dept. of Environmental & Biological Chemistry, Chungbuk National University, Cheongju 361-763, Korea, hangh@cbnu.ac.kr

20A

Bajwa, Rupneet and Yadav, Suman.

Phytoremediation System for theRemoval of Fluoroquinolone Group of Antibiotics

Rupneet Kaur Bajwa*, Guru Nanak Khalsa College of Arts; Suman Yadav*, SIES College of Arts, Science and Commerce; Shalini A Tandon,National Environmental Engineering Research Institute (N.E.E.R.I.)

Pharmaceuticals and personal care products (PPCPs) have been extensively used for decades for various purposes ranging from personal health, cosmetic reasons to veterinary purposes. They are members of a group of chemicals of emerging concern as increasing evidence suggests their ubiquity in the environment and potential adverse effects on non-target organisms and humans. The main reason why those pharmaceuticals may become harmful to the environment is that they are designed to affect biological objects.They have lipophilicity, which enables them to permeate biomembranes, and stability, which prevents their inactivation before the therapeutic effect. Therefore, drugs have the properties which enable them to accumulate in organisms and cause changes in water and soil ecosystems.

A pilot scale study was conducted for the removal of fluoroquinolone group of antibiotics from aqueous medium (Arnon-Hoagland's solution) by the use of wetland plant species. Five different wetland plant species which were able to treat municipal wastewater were screened for their removal efficiency for the commonly used antibiotics Ciprofloxacin, Gemifloxacin mesylate, Ofloxacin and Gatifloxacin. The most efficient plant species for each antibiotic were selected and tested again for confirmation of antibiotic removal efficiency at 50 mg/l of each antibiotic in Arnon-Hoagland solution. Taxodium distichum was found to be the most suitable for the removal of Ofloxacin, Gatifloxacin and Ciprofloxacin showing maximum removal of 21 mg/l, 23 mg/l, 36 mg/l, respectively and Canna indica was found to be the most suitable for removal of Gemifloxacin mesylate showing maximum removal of 33 mg/l.

Keywords: Constructed wetland, *Canna indica, Chrysopogon zizanioides, Taxodium distichum, Colocasia esculenta.*

* Rupneet Kaur Bajwa, Rupneet Kaur Bajwa, 43/t/j-1, wrly colony, Near DRM Office, Mumbai Central (E), Mumbai-400 008. Rupneet.k.bajwa@gmail.com Suman Yadav, 1, Hardev Yadav Chawl, Farid Nagar, Pratap Nagar Road, Bhadup (w), Mumbai- 400 078 Suman1789@gmail.com

21A

Franchi, Elisabetta

Molecular analysis and characterization of heavy metals tolerant and hydrocarbons degrader indigenous soil bacteria in a multi-process phytoremediation approach

Gloria Agazzi, Unimi-Bicocca; Paola Cosmina, Eni Donegani-TEAMB; Meri Barbafieri, CNR-ISE; Irene Rosellini, CNR-ISE; Gianniantonio Petruzzelli, CNR-ISE; Roberto Bagatin, Eni Donegani-TEAMB; Elisabetta Franchi*, Eni Donegani-TEAMB

Contaminated soils are frequently characterized by the simultaneous presence of heavy metals and hydrocarbons of various nature. For practical and effective remediation of different environmental contaminants, it is often advantageous to use multiple techniques or processes to accelerate remediation kinetics. Plant-based technologies are well suitable for removing low to moderate levels of contamination since several vegetable species are capable to uptake and accumulate heavy metal ions but many plant species are quite sensitive to organic contaminants and do not grow or they grow slowly producing insufficient biomass. The use of bacteria as a pretreatment consuming organics in the soil can significantly promote the phytoremediation process.
Present work is related to a project of phyto requalification of a disused industrial district located in Northern Italy where chemical analysis of soil revealed amount of copper, nickel and aliphatic hydrocarbons (mostly C_{19}-C_{36}) exceeding the legal limits. As we expected, germination of *Brassica juncea* seeds in this soil was completely suppressed and indigenous hydrocarbon oxidizing microrganisms were selected in order to performe a bioaugmentation step before the true phytoremediation. The isolated microrganisms, characterized by 16 rRNA gene sequencing, have proved to belong to genera such as *Gordonia, Microbacterium*, *Nocardia, Achromobacter, Nitrobacter, Ralstonia,* well-known for their ability to breakdown a lot of different organic pollutants.
A microbial consortium made of these heavy metals tolerant and hydrocarbon degrader strains were used as inoculum producing a positive effect on seeds germination. Preliminar data of the assisted phytoremediation approach and molecular analysis of microbial associated consortia will be presented.

Keywords: soil, phytoremediation, hydrocarbon oxidizing bacteria

* Elisabetta Franchi, Via Maritano 26, 20097 San Donato Mil.se, Italy,
elisabetta.franchi@eni.com

22A

Dupuy, Joan

Response of maize (*Zea mays*) to phenanthrene root exposure

Joan Dupuy*, LSE; Stéphanie Ouvrard, LSE; Thibault Sterckeman, LSE; Pierre Leglize, LSE

Phytoremediation technology is a cost-effective plant-based approach and environmental-friendly cleanup solution that has proved its efficiency to deal with persistent organic pollutants (POP) such as polycyclic aromatic hydrocarbons (PAH). However, those compounds have proved toxic to plants (Wittig et al. 2003). Therefore phytoremediation applicability and efficiency may be limited by the survival and the growth of plants. Thus, better knowledge on the impact of organic pollutants on plant's functioning, especially on root system modifications, is necessary for phytorestoration perspective. The aim of this study is to contribute to the understanding of the impact of phenanthrene (PHE), a representative PAH, on the functioning of maize (*Zea mays*). A culture was conducted in growth chamber under controlled conditions on artificially contaminated substrate (quartz sand) with increasing levels of PHE up to 750 mg PHE kg^{-1}. After four weeks, plants exposed to PHE had significantly decreased biomasses, despite a more important allocation to root system. PHE exposure also strongly inhibited the root system development with limited root hairs. These modifications were associated to differentiated water content and nutritional patterns, withering leaves, weaker photosynthesis and transpiration. Those results suggest an abnormal carbon fixation and/or nutrition in the presence of PHE. Two main hypotheses may be proposed. First, this molecule may induce drought stress, leading to inhibition of photosynthesis and nutrition and as a consequence, diminution of the growth. Alternatively PAH may affect root functioning and particularly nutrient uptake, which in turn would impact the whole plant functioning.

Keywords: PAH, maize, phytoremediation, plant's functioning, root system

*Joan Dupuy, Laboratoire Sols et Environnement, Université de Lorraine/INRA, 2 avenue de la Forêt de Haye, TSA 40602, F-54518 Vandœuvre-lès-Nancy cedex, France. joan.dupuy@univ-lorraine.fr

23A

Ahmadpour, Parisa

Evaluation of Cadmium Bioaccumulation and Translocation in *Acacia mangium* Grown in a Contaminated Soil

Parisa Ahmadpour*, Ports and Martime Organization (PMO) and Universiti Putra Malaysia; Fatemeh Ahmadpour, Isfahan University of Technology and Pars Special Economic Energy Zone; M. Soleimani and Farhad Hosseini Tayefeh Pars Special Economic Energy Zone

As a non-essential element, Cd can be highly toxic to plants and animals even at low concentrations.Phytoremediation is an approach in which plants are applied to detoxify contaminated areas. This study was conducted to evaluate the potential of *Acacia mangium* for remediation of soils contaminated with Cd. *S*eedlings were planted in soil spiked with Cd in amount of 0, 25, 50, 75, 100 and 150 mg kg^{-1} ($Cd_{0,}$ Cd_1, Cd_2, Cd_3, Cd_4 and Cd_5) for a period of five months. Control (Cd_0) showed the highest growth performance. Cd concentrations among plant parts were in the following trend: roots>stems>leaves. In order to evaluate the potential of species selected as phytoremediator, three indicators were used namely, biocentration factor (BCF, metal concentration ratio of plant roots to soil), translocation factor (TF, metal concentration ratio of plant shoots to roots) and removal efficiency (RE, total concentrations of metal and dry biomass of plants to total loaded metal in growth media).The highest total Cd concentration (321.18 ± 8.58 mg kg^{-1}) and total Cd removal based on total dry biomass (0.72± 0.03%) were found in Cd_5 and Cd_1, respectively. *A. mangium* showed high bioconcentration factor (BCFs>1) and low translocation factor (TFs<1). Hence, it may be inferred that this species has a potential to be used in phytoremediation of Cd-contaminated soil.

Keywords: phytoremediation, Cadmium (Cd), *Acacia mangium,* translocation factor (TF), Bioconcentration factor (BCF)

*Parisa Ahmadpour, Moddaress street, Maryam 17 alley, No 14, Post code: 7516638511-Boushehr- Iran, parisaahmadpour78@gmail.com

24A

Al-Baldawi, Israa

Optimized conditions for phytoremediation of hydrocarbons by*Scirpus grossus* in diesel exposure

Israa Abdulwahab Al-Baldawi*, Universiti Kebangsaan Malaysia; Siti Rozaimah Sheikh Universiti Kebangsaan Malaysia; Nurina Anuar, Universiti Kebangsaan Malaysia; Hassimi Abu Hasan, Universiti Kebangsaan Malaysia; Fatihah Suja, Universiti Kebangsaan Malaysia; Mushrifah Idris, Tasik Chini Research Centre, Faculty of Science and Technology, Universiti Kebangsaan Malaysia

This study investigated the optimum conditions for total petroleum hydrocarbon (TPH) removal from diesel-contaminated water using phytoremediation treatment with Scirpus grossus. In addition, TPH removal from sand was adopted as a second response. The optimum conditions for maximum TPH removal were determined through a Box-Behnken design. Three operational variables, i.e. diesel concentration (0.1, 0.175, 0.25% Vdiesel/Vwater), aeration rate (0, 1 and 2 L/min) and retention time (14, 43 and 72 days), were investigated by setting TPH removal as the maximum, diesel concentration and retention time within the given range, and aeration rate as the minimum. The optimum conditions were found to be a diesel concentration of 0.25% (V_{diesel}/V_{water}), a retention time of 63 days and an aeration rate of 0 L/min with an estimated maximum TPH removal from water and sand of 76.3 and 56.5%, respectively. From a validation test of the optimum conditions, it was found that the maximum TPH removal from contaminated water and sand was 72.5 and 59.0%, respectively, which was a 5.0 and 4.4% deviation from the values given by the Box-Behnken design, providing evidence that S. grossus is a Malaysian native plant that can be used to remediate wastewater containing hydrocarbons.

Keywords: Pilot scale reed bed, TPH removal, aeration, Box-Behnken design

*Israa Abdulwahab Al-Baldawi, Malaysia, 43600 UKM Bangi, Selangor, israaukm@gmail.com

25A

Guthrie, Nichols Elizabeth

Utilizing Stable Isotopes of Water in Tree Xylem to Evaluate Groundwater Contamination from an Inactive Hog Lagoon in North Carolina

Nichols Elizabeth Guthrie*, North Carolina State University; Maddalena, Damian, North Carolina State University

Imbalances in nutrient cycling have the potential to alter terrestrial, riverine, lacustrine, and oceanic ecosystems. Large animal agricultural operations are one source of nutrient enrichment, where common practice includes the storage of animal waste in open lagoons and the application of waste on agricultural fields. Stable isotopes have proven to be useful for monitoring enrichment in ground and surface waters. Recent efforts have coupled stable isotope hydrology with geostatistical modeling to generate continuous visualizations of ecohydrological isoscapes. This research uses stable isotopes and spatial modeling to understand the water source use dynamics of trees on a hillslope in the Piedmont region of North Carolina relative to an inactive hog lagoon. Field measurements of $\delta^{18}O$ and $\delta^{2}H$ in tree xylem are used in conjunction with interpolation methods to generate isoscape surfaces for the exploration of the potential influence of the hog lagoon on the subsurface nutrient load of the study hillslope. The project contributes to the growing science of isoscape generation as a phytomonitoring tool for groundwater contamination from hog lagoon leakage.

*Elizabeth Guthrie Nichols, North Carolina State University, Department of Forestry and Environmental Resources, College of Natural Resources, 3120 Jordan Hall Raleigh, NC 27695-8008

Coulon, Kelly

A Sustainable Approach to Wastewater Treatment in New York

Kelly Coulon*, Roux Associates Inc.; Amanda Ludlow, Roux Associates Inc.

A Constructed Treatment Wetland (CTW) was designed and constructed to replace components of an aging and undersized conventional sanitary wastewater treatment system at a small-animal breeding facility in Upstate New York. Roux Associates worked with the client's team to integrate their wastewater treatment needs to design an innovative enhanced subsurface flow CTW system.

Two parallel CTW cells were incorporated into the design to provide flexibility for operation and maintenance. The CTW cells were planted with native emergent marsh plants to filter suspended particulate matter and provide additional surfaces for microbial growth. Water levels in CTW systems are maintained below the surface of the media through passive hydraulic control structures; hence no standing or pooled water occurs on the cell surface. This design feature eliminates undesirable odors, propagation of mosquitoes, personnel and/or wildlife exposure concerns, and freezing in the winter.

Finally, the CTW design was enhanced through the incorporation of a patented aeration system to deliver continuous aerobic conditions into the subsurface treatment media. This enhancement reduced the retention time, and thus size, from a typical CTW by 50%, while simultaneously enhancing year round predictable performance.

All effluent sampling results to date are in compliance with the limitations on the SPDES permit. In fact, the effluent concentrations of CBOD, TSS, ammonia nitrogen, and fecal coliforms have been consistently non-detectable. The CTW system requires less maintenance compared to the conventional wastewater treatment system, making it a reliable and sustainable approach to treat sanitary wastewater.

Keywords: constructed treatment wetland, subsurface flow, sanitary, aeration

*Kelly Coulon, 209 Shafter Street, Islandia, NY kcoulon@rouxinc.com

27A

Vaca-Mier, Mabel

Bioremediation of soil contaminated with burnt motor oil by means of composting and phytoremediation.

Luisa Escobar-Alvarado, UAM; Mabel Vaca-Mier*, UAM; Neftalí Rojas-Valencia,UNAM; Raymundo López-Callejas, UAM; Julio Flores-Rodríguez, UAM

The inappropriate management and disposing of hazardous waste, such as burnt motor oil can cause environmental and health issues due to the toxicity of the pollutants which in most cases contaminate soils. Among the available technologies to remediate this situation, the use of biological technologies that can promote the degradation of hydrocarbons is quite promising. In this work we present the study of the degradation of total petroeleum hydrocarbons (TPH) from used motor oil in soil (32,000 mg TPH/kg soil), through the combination of composting followed by phytoremediation Two different compost piles were made, one using only yard trimmings and the other one using yard trimmings combined with slices of the cladodes of a Mexican type of cactus (*Opuntia ficus*). And were mixed with the contaminated soil in a 2:1 relation (w/w). After 6 weeks of composting, a reduction of more than 18% TPH was observed and this soil was used to grow three different plant species; *Medicago sativa*, *Trifolium pratense*, and *Lolium perenne*. After 35 days of seeding the contaminated soil, the compost with only yard trimmings and *Lolium perenne* showed the highest TPH removal efficiency (54.2%). One of the disadvantages of biological technologies is the required time. However these green technologies could be more inexpensive and less invasive for the environment.

Keywords: soil, hydrocarbon, compost, phytoremediation, burned motor oil

*Mabel Vaca-Mier, UAM, Universidad Autónoma Metropolitana, Azcapotzalco, Av. San Pablo 180, Col. Reynosa Tamaulipas mvm@correo.azc.uam.mx

28A

Al-Hamdani, Safaa

Evaluation of Kudzu in Lead and Chromium Phytoremediation

Safaa Al-Hamdani*, Jacksonville State University; Kristin Schwarzauer, University of Alabama at Birmingham

This study was carried out to evaluate kudzu (***Pueraria montana* var. *lobata***(Willd.)) in lead (100 and 200 mg l^{-1}) and chromium (4,8, and 12 mg l^{-1}) phytoremediation. The plants were grown hydroponically in a separate greenhouse experiment to evaluate the impact of the selected heavy metal on plant growth, photosynthetic pigments, photosynthesis, and stomata conductance. Additionally, concentrations of phenolic compounds and anthocyanin were determined. Root accumulation of lead and chromium was significantly higher than in the shoot. Total phenolic compounds increased with the presence of lead in the Hoagland's solution. Photosynthetic rate, stomata conductance, chlorophyll *a* and chlorophyll *b*, carotenoids, and anthocyanin were not different ($P \leq 0.05$) among the treatments, with the exception that carotenoids were significantly higher in plants growing in the presence of EDTA without lead compared to 200 mg l^{-1} lead concentration. Kudzu accumulated most of the lead and chromium in the root and therefore can be considered as a rhizofiltrator. As kudzu was able to accumulate 1.02% (w/w) of lead it can be considered a hyper-accumulator. Chromium accumulation was significantly higher in the root than the shoot. Kudzu growth, photosynthetic rate, stomata conductance, and chlorophyll concentration declined as the chromium concentration increased. Kudzu demonstrated its ability to survive at chromium concentrations up to 8 mgl^{-1} in the root environment.

Keywords: Kudzu, chromium, lead, plant growth, photosynthesis

*Safaa Al-Hamdani, Jacksonville State University, Jacksonville AL sah@jsu.edu

29A

Rylott, Elizabeth

Using *Arabidopsis thaliana* as a model plant species to investigate gold and palladium uptake, nanoparticle formation and subsequent catalytic potential

Elizabeth L. Rylott*, University of York; Andrew F. Taylor, University of York; Helen L. Parker, University of York,; Andrew J. Hunt, University of York; Jennifer R. Dodson,University of York;James H. Clark, University of York;Christopher W.N. Anderson, Massey University; Neil C. Bruce, University of York

The ever-increasing use of gold and platinum group metals in new technologies is causing concerns over the long-term availability of these metals, and highlighting the need for innovative technologies to recapture and exploit these wasted resources. Plants can be exposed to significant levels of these metals in the environment from naturally occurring sources, as the result of mining activities or more recently resulting from the escalating use of nanoparticles in industry. We have investigated the biological response and subsequent accumulation of nanoparticles of gold and palladium in plants. Although the uptake of most metal cations by plant transporters is well characterized, little is known about the uptake of gold, which exists in soil predominantly in a zero-valent state (Au0). Using *Arabidopsis thaliana* (Arabidopsis) as a model system, we show the down-regulation of a discreet number of genes known to be involved in the transport of copper, cadmium, nickel and iron. Using hydroponic systems to dose Arabidopsis with ionic solutions and nanoparticle suspensions of gold, our results indicate that gold is taken up in an ionic form. Following uptake, accumulation of nanoparticles occurs predominantly in the roots, although significant levels of metal are transported to the aerial parts of the plant. Phytomining exploits the ability of plants to accumulate metals from the surrounding environment; however, the resulting plant-metal material has yet to be exploited as a materials resource. We report on the ability of palladium nanoparticles in Arabidopsis that can be utilized, without necessity for extraction, in a range of Heck and Suzuki coupling reactions reaching yields of 81 %. These plant-derived catalysts perform well when compared to currently used palladium catalysts.

Keywords: gold, palladium, nanoparticles, biocatalyst, Arabidopsis

*Elizabeth L. Rylott, CNAP, Department of Biology, University of York, Wentworth Way, York, YO10 5DD, UK. liz.rylott@york.ac.uk

30A

Janssen, Jolien

Valorization of metal-contaminated soil with willow: using plant-associated bacteria to improve biomass production and metal uptake

Jolien Janssen*, Hasselt University; Sarah Croes, Hasselt University; Nele Weyens, Hasselt University; Jaco Vangronsveld, Hasselt University; Robert Carleer, Hasselt University

Metal-phytoextraction often requires long periods of time before guideline values can be reached. An economically attractive alternative is therefore the production of non-food crops for bioenergy or as feedstock for chemical industry since it combines remediation of contaminated soils with sustainable use and valorization. The main limiting factors during metal-phytoremediation are metal availability in soils, metal uptake and translocation in plants and metal phytotoxicity.

To improve biomass production and metal extraction of short rotation willow, we investigated the use of plant-associated bacteria which can have a beneficial effect on plant growth and metal uptake and translocation. Bacteria isolated from *Salix viminalis* were screened for their plant growth-promoting characteristics (e.g. production of indole-3-acetetic acid (IAA) and 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase) as well as for characteristics enhancing the uptake of toxic metals (e.g. production of siderophores and organic acids). Five strains were selected for a greenhouse inoculation experiment with cuttings of *S. viminalis* planted in Cd-Zn-Pb contaminated soil. This work summarizes biomass production of the inoculated cuttings and metal concentrations in the produced biomass.

Three of the selected strains, genotypically identified as *Pseudomonas* sp., *Rahnella* sp. and *Sphingobacterium* sp., increased biomass production as well as the extraction of Cd and Zn out of the soil. Thus, inoculating willow with the appropriate plant-associated bacteria has the potential to improve biomass production on contaminated land and even to shorten the clean-up time. Future experiments should include more promising bacterial strains as well as the effect of (re-)inoculation of willow cuttings on the longer term.

Keywords: phytoextraction, willow, plant-associated bacteria, cadmium

* Jolien Janssen, Hasselt University, Agoralaan building D, 3950 Diepenbeek, Belgium, jolien.janssen@uhasselt.be

31A

Parisien, Michele

Phytoextraction and phytostabilization of cadmium-contaminated soil in Peterborough, ON

Michele Parisien*, RMCC; Barbara Zeeb, RMCC; Allison Rutter, Queen's University

Cadmium pollution in the environment is of concern due to potential risks to both human and ecological health. Current remediation options for cadmium-contaminated soil, such as excavation and landfilling, can be expensive and destructive to soil structure and the surrounding ecosystem, and limit future application and value of the affected area. It is therefore important to develop cost-effective, eco-friendly remediation alternatives to those presently in use. Phytoextraction and phytostablization are two such alternatives, and we will present our work evaluating their potential as tools to clean up cadmium-polluted soil at a contaminated site in Peterborough, ON. Our first focus was to identify potential Cd phytoextractors, native to the Peterborough region, and then investigate their inherent ability to extract cadmium from the affected soil. A second focus of this work is to investigate biochar as a potential end-step to immobilize residual cadmium left in the soil after maximum phytoextraction has been achieved. Biochar is a charcoal-like soil amendment, and its unique properties make it a particularly useful sorbent for a variety of soil contaminants, while also improving the quality of soil. The results of our research will determine whether phytoextraction and phytostabilization with biochar are feasible options to remediate cadmium-contaminated soil at this site. Our research will also contribute to the relatively small collection of data available concerning the use of Ontario-native plants for phytoextraction.

Keywords: cadmium, phytoextraction, phytostabilization, biochar

* Michele Parisien, 13 General Crerar Cres., Kingston, ON, Canada michele.parisien@rmc.ca

32A

Kalogerakis, Nicolas

Rhizodegradation of bisphenol A by the halophyte *Juncus acutus:* effect of bioaugmentation

Evdokia Syranidou, TU-Crete; Stavros Christofilopoulos, TU-Crete; Philippe Corvini, FHNW; Nicolas Kalogerakis*, TU-Crete

The effectiveness of bioaugmentation with contaminant degrading microbes in rhizodegradation applications has not been well established as of yet. In this work (funded by FP-7 project MINOTAURUS) we examined the contribution of two *Sphingomonas* strains in the degradation of bisphenol A [BPA, 2,2-bis-(4-hydroxyphenyl)-propane] in pot experiments. In particular, a plant-associated cultivable endophytic BPA-degrading *Sphingomonas* strain isolated from the halophytic plant *Juncus acutus* was used and compared to the *Sphingomonas* sp. strain TTNP3 – a well-known BPA-degrader.

The maximum degradation rate by both strains utilizing BPA as the sole carbon source in an oligotrophic environment was determined in microcosm experiments and the TTNP3 strain was found superior. Subsequently, a series of pot experiments wasperformed. The following seven treatments were tested: (1) soil (for background level of enzymatic activity without plant); (2) *Juncus acutus* planted in soil (for background level of enzymatic activity with plant); (3) soil spiked with 30.5 mg-BPA/pot; (4) soil spiked with 30.5 mg-BPA/pot and inoculated with *Sphingomonas* sp. strain TTNP3; (5) *J. acutus* planted in soil spiked with 30.5 mg-BPA/pot; (6) *J. acutus* planted in soil spiked with 30.5 mg-BPA/pot and inoculated with *Sphingomonas* sp. strain TTNP3; (7) *J. acutus* planted in soil spiked with 30.5 mg-BPA/pot and inoculated with endophytic *Sphingomonas* strain. The mass of BPA in the soil and aqueous phases was measured and overall degradation was monitored. The population of *Sphingomonas* strains and the enzymatic activity of the cytochrome P450 were also monitored. The overall results show the advantage of bioaugmentation with a high BPA-degrading strain.

Keywords: rhizodegradation, bisphenol-A, bioaugmentation, endophytic bacteria

* Nicolas Kalogerakis, Department of Environmental Engineering, Technical University of Crete (TU-Crete), Polytechneioupolis, 73100 Chania, Greece nicolas.kalogerakis@enveng.tuc.gr

33A

Tombo, Elie F. I.

Flux of the chemical compounds within the Botelary River system, Cape Town, RSA

Elie F. I. Tombo*, CPUT; Abraham Thomas, Council for Geosciences; Stam Ed, Centre for Conservation Science National Zoological Gardens of South Africa; Wisemen Chingombe, Bindura University of Education Science

Pollution of the Bottellary River through surface runoff in the catchment is a matter of concern. The river receives pollutants from the land use within the catchment, thereby affecting water quality in the river. This study aimed to assess the concentration of chloride, nitrate nitrogen, phosphorus, total suspended solids, electrical conductivity, dissolved oxygen with the catchment's land use, as well the distribution of those compounds along the river and compare those values with the South African Water Quality Guidelines for Aquatic Ecosystems and for irrigation (DWAF, 1996a, 1996c). A two-factorial A One-way Analysis of Variance (ANOVA) without replication to assess the distribution of compounds along the river. Prior to modelling and the calculation of pollutants concentrations in the catchment, a land use map of the catchment was prepared using an integrated approach. The results of the study revealed differences of the concentrations of pollutants from one land use to another while, a P-value of compounds at all sections is above 0.5, except chloride. The concentrations of some compounds are below the Target Water Quality Range (TWQR) set by the Department of Water Affairs and Forestry (DWAF, 1996a, 1996b, 1996c) while, the concentrations of chloride, nitrate nitrogen, electrical conductivity, suspended solids, are higher than the TWQR (DWAF, 1996a, 1996b, 1996c). Based on the above findings water of the Bottelary River can have negative effects on the environment and human lives. It was recommended that, environmentally friendly practices must be observed in order to decrease the pollution and prevent further river pollution.
Keywords: Land use/land cover, Water Chemistry, Water quality, NPS model data, Bottellary River catchment

* Elie F. I. Tombo, Department of Environmental and Occupational Studies, Cape Peninsula University of Technology, Room 3.56, PO Box 652 Cape Town 8000, South Africa. Telephone: (027) 21460 9050 / Fax: (027) 214609042, elie.tombo@gmail.com

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Njoku, Kelechi L.

The Differential Potentials of Three Plants to Remediate Crude Oil Polluted Soil

Kelechi L. Njoku*, UNILAG; Modupe O. Akinola, UNILAG; Chioma M. Nkemdilim, UNILAG; Mojeed P. Ibrahim, UNILAG; Ayokunle S. Olatunbosun, UNILAG

The potentials of two weed plants (*Panicum maximum* and *Eleusine indica*) and a crop plant (*Pennisetum glaucum*) in remediation of crude oil contaminated soil wwere investigated in this study. The crop plant was obtained from the NAGRAB Ibadan Nigeria while the weed plants were sourced from different locations in the University of Lagos, Akoka Lagos, Nigeria. The each soil pot was contaminated with different levels of crude oil to obtain 1%, 2%, 3%, 4% and 5% levels of contamination. The vegetated and non vegetated soils were analysed for total petroleum hydrocarbon (TPH) level, moisture level, organic matter content and pH level at the beginning and at the end of the study. Results show reduction of TPH level in the soils at the end of the study with significant reduction in the vegetated soils. The other parameters studied were also affected by the growth of the plants. The results of the study show that the plants have differential effects on the soil parameters with *Pennistum glaucum* having the greatest impact on the TPH level of the soil.

Keywords: Remediation, Crude oil, Weed Plants, Crop Plants, Differential effects.

*Kelechi L. Njoku, Department of Cell Biology and Genetics, University of Lagos, Lagos Nigeria, kecynjoku@gmail.com, knjoku@unilag.edu.ng

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Lee, JongKeun

Application of anaerobic digestion to disposal of heavy metal-contaminated byproducts from phytoremediation sites

JongKeun Lee*, Seoul National University; Xin Zhao, Seoul National University; Jaemaro Han, Seoul National University; Dongwook Kim, Phygen Inc.; Jae Young Kim, Seoul National University

Recently, phytoremediation an emerging technology as a cost-effective green technology that uses plants to clean up contaminated areas. The disposal of highly contaminated byproduct (i.e., plant biomass) following phytoremediation should be considered for successful process. Several methods of contaminated byproduct disposal have been researched, including composting, incineration, ashing, pyrolysis, direct disposal, and anaerobic digestion. Among them, anaerobic digestion for byproduct disposal after phytoremdiation was focused in this study. The objectives of this study were to apply the BMP (Biochemical Methane Potential) test as a tool for evaluating the anaerobic digestion process using sunflower (i.e.,*Helianthus annuus*) grown in both heavy metals-contaminated and uncontaminated soils, and maximum methane production was observed. BMP tests performed in 250-ml bottles at 35°C and 150 rpm for 60 days, gas production and gas composition were analyzed to assess the efficiency of the anaerobic digestion on the BMP test.Heavy metal contents were 3.21 and 2.82 for Cd, 13.13 and 8.86 for Pb, 56.02 and 51.89 for Zn, and 1.45 and 0.21 mg/kg (dry basis) for Ni in the sunflowersgrown contaminated area and uncontaminated area, respectively. Results showed that uncontaminated plants were faster to reach for maximum methane production than highly contaminated sunflowers. However, lag period and maximum methane production showed the similar trends in both byproducts. From theseresults, heavy metals in plants may change the time to reach for maximum methane productionin anaerobic digestion.

Keywords: phytoremediation, *Helianthus annuus,* byproduct, anaerobic digestion, BMP test

*JongKeun Lee, Seoul Nat'l Univ., Gwanangno 599, Gwanak-gu, Seoul,Republic of KOREA, jklee@snu.ac.kr

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Zhao, Xin

Comparison of Cd, Pb, Ni, Zn and As phytotoxicities under aqueous and soil conditions

Xin Zhao*, Seoul National University; JongKeun Lee, Seoul National University; Jaemaro Han, Seoul National University; Dongwook Kim, Phygen Inc.; Jae Young Kim, Seoul National University

Germination tests for assessing heavy metal phytotoxicities were generally conducted in water, i.e., aqueous solution of heavy metals.However, water is not the main target of phytoremediation and soil is. The results of germination test in water are inapplicable to soil directly. In order to overcome this limitation, germination tests in soil used to be performed. However,the tests offer just one-off results because tests are conducted in the objective soils that have the specific contamination level and the results cannot be expanded. In other words, using those results we cannot obtain information about phytotoxicity trend depending on contamination levels (heavy metal concentrations of soil). Also, germination test in soil takes relatively high effort and costs. In this study, we are to develop germination test in soil, investigate the difference of Cd, Pb, Ni, Zn and As effects on sunflower germination between water and soil phases, and find relationships between germination and heavy metal concentrations in water and soil data through the regression analysis. Ultimately, this study suggests an empirical formula that makes it possible to predict phytotoxicity of soil using that of water.

Keywords: germination test, phytotoxicity, heavy metals, phytoremedaion

* Xin Zhao, Seoul Nat'l Univ., Gwanangno 599, Gwanak-gu, Seoul,Republic of KOREA
zhaoxin@snu.ac.kr

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White, Jason C.

Nanoparticle Co-exposure Alters the Toxicity and Accumulation of Persistent Pesticides in Agricultural Crops

Jason C. White*, Connecticut Agricultural Experiment Station (CAES); Roberto De La Torre-Roche, CAES; Joseph Hawthorne, CAES; Wenjun Cai, SUNY College of Environmental Science and Forestry (SUNY ESF); Lee A. Newman, SUNY ESF; Chen Wang, Southern Illinois University Carbondale (SIU); Xingmao Ma, SIU; Yingqing Deng, University of Massachusetts-Amherst (UMass); Baoshan Xing, UMass

Although the use of engineered nanomaterials (NM) has increased, the fate and effects of these substances in the environment is poorly understood. As an emerging class of contaminants, there is significant potential for NM interactions with co-existing chemicals. Direct molecular interactions between NM and co-contaminants may change either or both molecules, or NM may alter the ability of biota such as plants to tolerate or accumulate co-existing chemicals. A number of studies have been initiated in which the impact of NM co-exposure on the toxicity and accumulation of persistent pesticides by plants has been evaluated. The accumulation of DDE by zucchini, soybean and tomato grown in C_{60}-amended vermiculite increased by 30-65% compared to controls. In a soil containing 0.20 mg/kg weathered DDE, C_{60} co-exposure on had little impact on DDE accumulation. Ag nanoparticles (NP) suppressed DDE uptake by zucchini and soybean grown in vermiculite. Interestingly, NP Ag resulted in greater suppression of DDE accumulation that did equivalent bulk or ion exposures and data suggests that Ag-mediated closure of aquaporins may be responsible for decreased uptake. A study currently underway involves corn, soybean, zucchini, and tomato being grown in soil containing weathered chlordane (2 mg/kg) and DDE (0.2 mg/kg) that was amended with 0, 500, 1000, or 5000 mg/Kg C_{60} or multiwalled carbon nanotubes. The finding that engineered nanomaterials can significantly alter the accumulation of pesticides in plants may have significant implications for food safety, as well as for the movement of pesticides and other organic contaminants through the environment.

Keywords: Nanoparticles, Persistent Organic Pollutants, Fullerenes, Co-exposure, Nanotubes

*Jason C. White, Department of Analytical Chemistry, Connecticut Agricultural Experiment Station, 123 Huntington Street, New Haven, CT 06504 USA; Jason.White@ct.gov

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White, Jason C.

Trophic Transfer Potential of Cerium Oxide Nanoparticles Through a Terrestrial Food Chain

Jason C. White* , Connecticut Agricultural Experiment Station (CAES); Roberto De La Torre-Roche, CAES; Joseph Hawthorne, CAES; Craig Musante, CAES; Lee A. Newman SUNY College of Environmental Science and Forestry; Xingmao Ma, Southern Illinois University Carbondale; Baoshan Xing, University of Massachusetts-Amherst

Although the use of engineered nanomaterials (NM) has increased dramatically, the fate and effects of these substances in the environment is poorly understood. Given that NM may represent an emerging class of contaminants, there is significant potential for NM interactions on terrestrial biota such as plants, as well as for bioaccumulation and biomagnification of these materials through food webs that may or may not include humans. In spite of this fundamental concern, very few studies have addressed the potential trophic transfer and biomagnification of NM in terrestrial environments. Studies have been initiated in which 0-1000 mg/kg bulk or nanoparticle (NP) cerium oxide have been added to an agricultural loam. *Cucurbita pepo* (zucchini) was then grown in the cerium-amended or control soils for approximately 21 days and element content of the root and shoot tissue was determined by ICP-MS. Fresh shoot tissue that had been exposed to 0-1000 mg/kg bulk or NP cerium oxide was used to feed herbivorous *Acheta domesticus* (cricket) populations for up to 28 days. Select cricket tissues were digested and cerium content was determined by ICP-MS. Live crickets that had consumed zucchini shoots exposed to 0-1000 mg/kg bulk or NP cerium oxide were then used to feed carnivorous *Tenodera sinensis* (mantid) or *Lycosidae* (wolf spider) populations. The cerium content of carnivorous animal populations was also determined by ICP-MS. The potential transfer of engineered nanomaterials by plants through food chains, regardless of biomagnification, has implications for agriculture, remediation and human exposure.

Keywords: Nanoparticles, Trophic Transfer, Biomagnification, Cerium Oxide

*Jason C. White, Department of Analytical Chemistry, Connecticut Agricultural Experiment Station, 123 Huntington Street, New Haven, CT 06504 USA; Jason.White@ct.gov

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Reynolds, Ray

Selenium Hyperaccumulators and Their Associated Endophytes, A Phytoremediation Partnership?

Ray Reynolds*, Colorado State University; Lucian Staicu, Colorado State University; Martina Novakova, ICT Prague; Daniel Van der Lelie, RTI International; Elizabeth Pilon-Smits, Colorado State University

Endophytes show great promise in phytoremediation, and biofortification. Endophytes can have beneficial effects on plant growth, pathogen resistance, as well as an ability to enhance plant tolerance and extraction capability of various contaminants. Particularly interesting in our work are endophytes that live within selenium hyperaccumulators. We have isolated 79 endophytes from root and leaf tissues of two Colorado native hyperaccumulators: *Stanleya pinnata*, and *Astragalus bisulcatus*. 16s ribosomal DNA primers were used to identify these endophyte isolates. Some isolates show characteristics which promote plant growth including: Indole acetic acid production, phosphate solubilization, and acetoin production. Some isolates also show chitinase activity and protease activity, which may defend the plant against pathogens. All isolates are extremely tolerant to very high levels of both selenate and selenite. Currently eight (four from *S. pinnata* and four from *A. bisulcatus*) of the most promising endophytes are being tested for their role in plant accumulation and tolerance to selenium. *Stanleya pinnata* and two other species from Brassicaceae have been inoculated with the four endophytes isolated from *Stanleya pinnata*. Similarly, *Astragalus bisulcatus* and 2 other species from Fabaceae have been inoculated with the four endophytes isolated from *Astragalus bisulcatus*. Both the Brassicaceae and Fabaceae groups are being grown with and without selenate. We aim to begin to elucidate the role of endophytes in plant tolerance and accumulation of selenium. We hope, by this study, to show the potential of endophytes in the selenium biofortification of crops as well as their use in phytoremediation.

Keywords: Phytoremediation, biofortification, endophyte, selenium, hyperaccumulator.

*R. Jason B. Reynolds 1878 Biology dept., Colorado State University, Fort Collins, CO
Jason.Reynolds@colostate.edu

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Nelson, Sheldon

Combining Phytoremediation with Habitat Restoration

Sheldon Nelson*, Chevron Energy Technology Company

The residual and dissolved ammonium and nitrate present in soil and groundwater at a 2.5-acre former agricultural chemical storage facility in the Central Valley of California is being addressed by a variety of tree species planted on portions of the property. Experience at other sites impacted by similar compounds at comparable concentrations suggests that a correctly developed phytoremediation approach has a reasonable chance of passively reducing the subsurface levels of these constituents in an acceptable time period. A planned expansion of the tree-based phytoremediation system, and irrigation equipment and soil quality improvement, will also allow a section of the property to be developed as pollinator species habitat, compatible with the primary phytoremediation strategy. A sub-set of the trees to be installed will be selected based on their pollen and nectar availability, and will function as part of the expanded phytoremediation system. Additional perennial shrubs and forbs will also be added to enhance the pollinator nutritional value of the habitat for as much of the growing season as possible. Ground disturbance will also be minimized, if possible, to allow nesting area for native pollinator species. The proposed ecologic re-use of the property will seamlessly enhance local wildlife habitat, provide a direct benefit to the neighboring fruit and vegetable farms, and serve as components of the remediation strategy.

*Sheldon Nelson, 6001 Bollinger Canyon Road, San Ramon, California 94583
snne@chevron.com

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Wang, Dan

**Phytoextraction Ability of *Amaranthus mangostanus* L.
FromContaminated Soils with Cs and Sr**

Dan Wang*, Southwest University of Science and Technology; Xiaoxue Zhang, Southwest University of Science and Technology; Changhe Xu, Southwest University of Science and Technology; Muzhi Zhong, Southwest University of Science and Technology; Xuegang Luo, Defense Key Laboratory of the Nuclear Waste and Environmental Security, China; Yunlai Tang, Southwest University of Science and Technology

The contamination of soil with^{90}Sr and ^{137}Cs has long-term radiological and health impacts due to their long half lives and chemical similarities with two essential elements required for plant growth, Ca^{2+} and K^{+}, respectively.The selection of hyperaccumulators for^{90}Sr and ^{137}Cs, their uptake and accumulattion ability are the most important factors to impact the remediation efficiency. *Amaranthus mangostanus* L. was chosen as the research object in this experiment in the hydroponic medium and in the pot trial to investigate the characteristics of uptake ,transpotation , accumulatation and the physiological mechanish in ^{133}Cs and^{88}Sr polluted soils. The result showed that the ^{133}Cs and ^{88}Srcan be transported easily from root part to above-ground part byAmaranthuswhen the ^{133}Cs and ^{88}Sr concentration in the soil was high(1-5mmol/kg),their Tfs were higher than 1. The highest ^{133}Cs and ^{88}Sr contents of total plant was 3.54±0.15 and 0.57±0.21 mg.g^{-1}dw, respectively.Amaranthus can uptake more^{133}Cs than ^{88}Sr in same situations, but their TFs were similar . Higher concentrations of ^{88}Sr in the soil had stronger effect on the biomass of amaranth than that of^{133}Cs stress. The Ratio of^{133}Cs or^{88}SrContens in the plant with the contents in a pot was the highest in the 0.1(mmol/kg)treatment ,and was 19.88% or 23.97%, respectively .Physiological response of amaranth to ^{133}Cs and ^{88}Sr stress was researched in this experiment. *Amaranthus mangostanus L* showed a great potential to remediate the Cs and Sr contaminated soil.

Keywords: ^{133}Cr, ^{88}Sr, phytoremediation,accumulation, physiological response

*Dan Wang, College of Life Science and Engineering, Southwest University of Science and Technology, 59, Qinglong Road, Mianyang, Sichuan 621010, China wangdan@swust.edu.cn

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Mench, Michel

Field Evaluation of a Metal-Resistant Tobacco Variant and Two Mother Clones for Copper Phytoextraction at a Wood Preservation Site

Aliaksandr Kolbas,University of Brest; Michel Mench*, University of Brest; Rolf Herzig, PHYTOTECH Foundation;Lilian Marchand, University of Brest

A Cu-resistant somaclonal tobacco variant (NBCu 10-8-F1) and 2 mother clones (BaG and FoP) were cultivated at a wood preservation site with Cu-contaminated soils (239-1290 mg Cu kg^{-1} soil) and an uncontaminated control site. Influences of Cu exposure and soil treatments, i.e. untreated soil, compost with either dolomitic limestone (OMDL) or zerovalent iron grit (OMZ), on plant growth, mineral composition, and shoot Cu removal were measured. Shoots were harvested after three months. Total shoot DW yield varied between 0.8-9.9 Mg DW ha^{-1} yr^{-1} depending on tobacco cultivars, soil treatments, and soil Cu exposure. It peaked for all cultivars in OMDL plots at intermediate levels of total soil Cu. Soil amendments improved shoot Cu removal through increase in either shoot DW yield or shoot Cu concentration. The FoP clone at moderate Cu levelproduced the highest shoot DW yield. Shoot Cu concentration peaked (75 mg Cu kg^{-1}) with FoP plants in the OMZ soil. Increased shoot Cu concentration induced an ionome imbalance with increased Al, Fe, B and Mg concentrations and decreased P and K ones.Copper concentrations in plant parts were in decreasing order: roots > leaves > inflorescence> stem, whereas Cu mineral masses ranked as roots > stem = leaves > inflorescence. Shoot Cu removal (in g Cu $ha^{-1}yr^{-1}$) ranged from 15.4 to 261.3. For OMDL soils with high Cu exposure, the somaclonal variant had a higher shoot Cu removal than the mother clones. The use of these tobacco plants for sustainably phytomanaging Cu-contaminated soils was discussed.

Keywords: Cu removal, *Nicotiana tabacum* L., phytomanagement, phytoremediation, soil amendment

*Michel Mench, INRA, UMR BIOGECO 1202, Ecology of Communities, University of Bordeaux 1, Bât B2, avenue des Facultés, FR-33405 Talence, France. mench@bordeaux.inra.fr

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Nwaichi, Eucharia O.

Phenol Removal from Refinery Effluent using *Hevea Brasilliensis*

Eucharia O. Nwaichi, University of Port Harcourt*; T. Z. Warigbani, University of Port Harcourt

This study examines the performance of *Hevea brasilliensis* at Contaminant (Phenol and associated types) removal on effluent from Warri Refinery and Petrochemical Company. The data used in this research were generated from direct field measurements of Color, Temperature, pH, Electrical Conductivity, Total Dissolved Solid, Total Suspended Solids, Phenol, Cyanide, Salinity, Total Hydrocarbons, Dissolve Oxygen, Chemical Oxygen Demands, Biological Oxygen Demand, Turbidity, and some heavy metals profile (Hg,Pb,Cr,Cd, and Fe) in the refinery effluent. Effluent samples (treated and untreated) were characterized before and after the experiment and *H.brasilliensis*was grown hydroponically in triplicates for forty three (43) days to assess its performance using deionized water as control. Growth indices (plant height, root length leaf width, leaf area and leaf length) were monitored weekly for the duration of the experiment. Observedgrowth performance was luxuriant and up to 90% phenol removal was recorded for salted regimes in preference to 65% removal obtained for the unsalted regimes. Generally, results obtained from this investigation present *H.brassilliensis* as a candidate for phytoremediation of Phenol from refinery effluent.

Keywords: Refinery Effluent; Heavy metals removal; *Hevea brasiliensis*; Phenol removal.

*Eucharia O. Nwaichi, Department of Biochemistry, University of Port Harcourt, Port Harcourt, P. M. B. 5323 Port Harcourt, Rivers State, Nigeria. nodullm@yahoo.com

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Nwaichi, Eucharia O

Remediation of Oil-Contaminated Wetland by *Hevea Brasillensis*

Eucharia O. Nwaichi, University of Port Harcourt;M. O. Monano, University of Port Harcourt; P. A. Nwoha, University of Port Harcourt

The present investigation provides data on *Hevea brasilliensis'* performance at site clean - up. Effluent sample from a wetland around an abandoned well site in Mgbuoba, a Nigerian Niger Delta community was characterized prior to a hydroponic experiment using *H. Brasilliensis* for forty-three (43) days in the presence of white light and salted regime to assess its performance at contaminant removal. Deionized water was used as control and all experiment was done in triplicates. Observed levels of studied heavy metals (Cd, Pb, and Fe) were statistically significant at $p \leq 0.05$ and were reduced to 82%, 71% and61%) respectively. Salt treatment gave greater root uptake and were up to 16%,18% and12% respectively. Phenol degradation up to 85% success was recorded within study period. Growth indices also, gave statistically significant values that supported tolerance to expressed toxicity. Generally, results indicate excellent levels of extraction of contaminants leaving relatively low or non – detectable values, thus presents *H*. *brassilliensis* a candidate for phytoremediation of oil-related contaminated liquid effluent especially, a salt – assisted design.

Keywords: Oil-related effluent, Heavy metals removal,*Hevea brasiliensis*, Hydroponic experiment, Salt enhancement.

*Eucharia O. Nwaichi, Department of Biochemistry, University of Port Harcourt, Port Harcourt, P. M. B. 5323 Port Harcourt, Rivers State, Nigeria. nodullm@yahoo.com

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Hadi, Fazal

Enhanced phytoremediation of Cd-contaminated soil by *Partheniumhysterophorus* plant: Effect of gibberellic acid (GA_3) and synthetic chelator alone and in combinations

Fazal Hadi*, University of Malakand Chakdara KPK, Pakistan; Nasir Ali, University of Malakand Chakdara KPK Pakistan; Ayaz Ahmad, University of Malakand Chakdara KPK Pakistan

Gibberellic acid (GA_3) and ethylenediaminetetraacetic acid (EDTA) roles in phytoextraction of cadmium (Cd) contaminated soil by *Partheniumhysterophorus* plant was investigated. GA_3 (10^{-9}, 10^{-7} and 10^{-5} M) was applied as a foliar spray. EDTA was added to soil in a single dose (160 mg/kg soil) and split doses (40 mg/kg soil, four split doses). GA_3 and EDTA were used separately and in various combinations. *P. hysterophorus* was selected due to its fast growth and unpalatable nature to herbivores to reduce the entrance of metal into the food chain. Cd significantly reduced plant growth and dry biomass (DBM). The GA_3 alone increased the plant growth and biomass in Cd contaminated soil while EDTA reduced it. GA_3 in combinations with EDTA significantly increased the growth and biomass. The highest significant DBM was found in treatment T3 (10^{-5} M, GA_3). All treatments of GA_3 or EDTA significantly enhanced the plant Cd uptake and accumulation compared to control (C1 only Cd added). The highest significant root and stem Cd concentration was found in the combination treatment T11 (GA_3 10^{-5} M + EDTA split doses), while in leaves it was found in the EDTA treatments. The combination treatment T9 (GA_3 10^{-7} M + EDTA split doses) showed the significantly highest total Cd accumulation (8 times greater than C1). The GA_3 treatments accumulated more than 50% of the total Cd in the roots while the EDTA showed more than 50% in the leaves. GA_3 is environment friendly as compared to EDTA. Therefore, further investigation of GA_3 is recommended for phytoremediation research for the remediation of metals contaminated soil.

Keywords: Phytoextraction, Cadmium, *Parthenium hysterophorus*, EDTA, contaminated soil

*Fazal Hadi, Department of Biotechnology University of Malakand Chakdara 18800, KPK, Pakistan,   dr.fhadi@uom.edu.pk fazalbiotech@yahoo.com

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Sebastian, Abin

Biodynamic farming decrease cadmium accumulation in rice cultivars

Abin Sebastian*, University of Hyderabad; M. N. V. Prasad, University of Hyderabad

Biodynamic farming promises a self-sustaining phytotechnological approach where a holistic development and interrelationships of the soil, plants and animals exists. It is the ability of organic manure to immobilize toxic trace elements in soil that makes application of biodynamic farming in metal contaminated fields. Rice based agroecosystem depends on fertilizers to increase crop yield whereas phosphate fertilizers contaminated with cadmium (Cd) leads Cd accumulation in rice. In the present study; influence of soil type and organic manure were screened with regard to Cd accumulation in two Indian rice cultivars MTU 7029 and MO 16. It was found that vertisol prevents Cd accumulation in rice grain compare with alfisols. Application of organic manure such as cow dung and poultry cast in its raw form prevented Cd accumulation in rice. Enhancements in ecophysiological functions such as photosynthesis and mineral uptake of plants were observed in these treatments. But application of vermicompost prepared from these farmyard manures lead to Cd accumulation in rice plants because of enhancement of root growth. Cd accumulation also found as genome dependant where MO 16 accumulated low Cd compare with MTU 7029. Study could be summarized as rice cultivation in vertisol and fertilization with farmyard manures are beneficial to prevent Cd accumulation in rice plants. Hence biodynamic farming practice offers a sustainable phytotechnological approach to cultivate plants in Cd contaminated sites.

Keywords: cadmium, soil properties, soil amendments, ecophysiology, mineral nutrients

*Abin Sebastian, Department of Plant Sciences, University of Hyderabad, Hyderabad- 500046, India., abinhcu@gmail.com

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Oliveira, Juraci

Arsenic: Efficiency of the Phytoextraction Process and Enzymatic Mechanisms of Tolerance in Water Hyacinth

Juraci Oliveira, UFV*; Iulla Reis, UFV; Fernanda Farnese, UFV; Jose Cambraia, UFV

The efficiency of arsenic (As) phytoextraction, bioconcentration factor (BCF) and transfer factor (TF) were evaluated in water hyacinth plants (*Eichhornia crassipes*) subjected to As concentrations: 0.0, 0.2, 0.5, 0.8 and 1.0 mg L^{-1} (as $Na_2HAsO_4.7H_2O$), for 3 days. Toxic effects on growth and antioxidant defense system were also examined. The As content in roots increased with the increment of As concentration in the solution up to 0.7 mg L^{-1}, but in the leaves this increase was linear up to 1.0 mg L^{-1}. When subjected to 0.2 mg L^{-1}As the plants had extracted 97% of the element from the solution. At higher As concentrations the removal efficiency has been reduced, but still were able to remove more than 50% in the 1.0 mg L^{-1} As. The BCF values were smaller than 500 and the TF values were greater than 1.0 in As concentrations above 0.5 mg L^{-1}. This indicates that the increase in the absorption by water hyacinth resulted in greater translocation of this element to the leaves. There was a decrease in the concentration of H_2O_2 in water hyacinth exposed to the moderate concentrations of As, which indicates the effective action of antioxidant enzymes such as superoxide dismutase, catalase and peroxidase. Thus, it appears that in As concentrations below 0.5 mg L^{-1} water hyacinth plants maintains appropriate levels of defense mechanisms to tolerate this pollutant and it is possible efficiently remove it of the solution. So, this species may be indicated for phytoremediation of the aquatic environments polluted with As.

Keywords: antioxidant enzymes, phytoremediation, macrophyte.

*Juraci Oliveira, Av. P.H. Rolfs, s/n, UFV, Vicosa, MG, Brasil, jalves@ufv.br

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Keropian, Zohrab

Phytoavailability of lithium to *Brassica juncea* in acidic heterogeneous rhizosphere

Zohrab Keropian*, Concordia University; Maria Elektorowicz, Concordia University

Potential for phytoremediation and phytostabilization of lithium in lieu with vanadium and chromium on a formulated acidic heterogeneous growth media, engineered around lithium mine tailings, that was investigated in four phases;(1) an overall efficiency of the three metals removal, (2) bioaccumulation ratios of the three metals, (3) overall relative growth rate and (4) translocation index of the three metals in hyperaccumulant plant physiology. In a pot study that was conducted to assess the suitability of *Brassica juncea* (Indian mustard) in a phytoremediation process that was lingered for eighty six days under homogeneous growth conditions, irrigated bi-daily with organic fertilizer amended with LiCl. A post-harvest data analysis was achieved through ashing and the implementation of cold digestion procedure in a concentrated hydrochloric acidic matrix. In botanical efficiency parameters, the hyperaccumulant plant was twice as successful in phytostabilizing chromium and more than four times of vanadium in comparison to lithium. On the contrary it was extremely efficient in translocating and precipitating lithium inside its upper physiological compartments, rather than chromium and vanadium; thereby depicting the strong ability of the Indian mustard the hyperaccumulant plant for phytoextraction and phytostabilization in an acidic heterogeneous rhizosphere, despite an extremely low relative growth rate.

Keywords: *Brassica juncea*, phytostabilization, lithium, phytoremediation, growth media

*Zohrab Keropian, 118 Ivanhoe Crescent, Pointe-Claire, Quebec zohrabk@hotmail.com

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Amouei, Abdoliman

Comparison of three chemical extractants for available lead, cadmium and zinc in contaminated soils

Abdoliman Amouei*, Babol University of Medical Sciences; Zabihollah Yousefi, Mazandaran University of Medical Sciences; Masoumeh Tahmasbizadeh, Babol University of Medical Sciences

Availability of the heavy metals (Pb, Cd, and Zn) has been studied by the use of different additives on the soil of industrial areas of Amol. Collected soil samples, by complete mixed, were dried in oven, and after grinding they were passed through a polyethylene sieve with 2 mm diameter holes. Extraction process of heavy metals from soil has done by distilled water, calcium chloride, potassium nitrate, ammonium citrate and EDTA at different concentrations. The heavy metals have been measured by Atomic Absorption Spectrometer (AAS). Concentrations of Pb, Cd and Zn in the soils were determined as 50±12.5, 127±16.13510 and 3000±180 mic/gr respectively. Best concentration and extraction conditions for the heavy metals determined. Application of chemical additives such as EDTA and ammonium citrate plays an important role in dissolution of heavy metals and thus in increasing their availability in soil.

Keywords: availability, heavy metals, soil, additives

*Abdoliman Amouei, Department of Environmental Health Engineering, Faculty of Health, Babol University of Medical Sciences, Baol, Iran iamouei1966@gmail.com

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Amouei, Abdoliman

Removal of Cadmium(II) ions from Aqueous solution by Low cost adsorbent prepared *Helianthus annus* (Sunflower)

Abdoliman Amouei*, Babol University of Medical Sciences; Mohammad Hossein Ehrampoush, Shahid Sadoughi University of Medical Sciences; Fatemeh Asgharzadeh, Babol University of Medical Sciences; Mohammad Taghi Ghaneian, Shahid Sadoughi University of Medical Sciences

Cadmium is a contaminant of America by the Environmental Protection Agency (USEPA) is among the priority pollutants. Priority pollutants, pollutants that can cause cancer in exposed organisms, and mutagenesis are malformations. The purpose of this study the effect of the removal of cadmium from aqueous solutions is sunflower residuals. This experimental study was performed in laboratory scale and was performed on 200 synthetic samples in a batch system. In this study the effect of parameters such as contact time (5, 10, 15, 30, 45, 60, 120 min), pH (2, 4, 6, 7), cadmium concentration (15, 30, and 60 mg) and adsorbent doses (0.2, 0.6, 1 grams in 100 ml) was evaluated. finally the results were analyzed by kinetic models. The results showed that, cadmium removal efficiency was 95% after 24 hours. Optimum pH range is 6. Maximum absorption occurs in 5 minutes. Investigating absorption kinetic showed that Cadmium absorption by sunflower residuals follows pseudo-second-order model (R2 = 0.999). Maximum binding capacity was 20.2 mg/ g. On the basis of the results, the pH too low or too high, leading to lower rates are eliminated by increasing the solution pH from 2 to 6 removal efficiency of cadmium increased and higher than 7 again reduced. Cadmium removal Efficiency would decreases with increasing initial concentration of Cadmium and increasing with adsorbent mass.

Keywords: sunflower plant waste, aqueous solution, cadmium, absorption kinetic

*Abdoliman Amouei, Department of Environmental Health Engineering, Faculty of Health, Babol University of Medical Sciences, Baol, Iran iamouei1966@gmail.com

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Amouei, Abdoliman

Study of cadmium removal from aqueous solutions by sunflower powders and modeling using artificial neural network

Abdoliman Amouei*, Babol University of Medical Sciences; Fatemeh Asgharzadeh, Shahid Sadoughi University of Medical Sciences; Akbar Amooey, Mazandaran University

Cadmium is Hazardous and non-biodegradable material and migrates to food chain. In this paper, the removal of cadmium from aqueous solutions by sunflower powder (the natural biosorbent) was investigated. The experiments were performed in batch system. The effect of parameters such as contact time, pH, cadmium concentration and adsorbent dose were evaluated, the results showed that increasing of pH, contact time and adsorbent dose cause to increasing of efficiency of removal cadmium from aqueous solutions. The results were modeled by bisorption kinetics and a neural network with four hidden neurons, including the bias, was able to predict very accurately the concentration dependency of data. The predictions of the artificial neural network model fit the experimental data very accurately.

Keywords: Sunflower powder, Aqueous Two Phase, Biosorption, Biokinetics, neural network

*Abdoliman Amouei, Department of Environmental Health Engineering, Faculty of Health, Babol University of Medical Sciences, Baol, Iran iamouei1966@gmail.com

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Amouei, Abdoliman

The Effect of Chemical Additives on the Uptake and Accumulation of Pb and Cd in Native Plants of North of Iran

Abdoliman Amouei*, Babol University of Medical Sciences; Amir Hossein Mahvi, Tehran University of Medical Sciences; Kazem Naddafi, Tehran University of Medical Sciences

Using plants for cleaning up the soil contaminated with pollutants, especially heavy metals increased in the last decade. Decrease in the availability of heavy metals in soil by plants is one of the major challenges of phytoremediation. This study was conducted to determine the role of EDTA, ammonium citrate and ammonium phosphate in the mobility and availability of Pb and Cd in soil by native plants of Mazandaran Province. Three native plants of northern areas in Iran were studied. Lead and cadmium concentration in the soil and plant samples was determined by Atomic Absorption Spectrometry (AAS) Perkin-Elmer 603. In EDTA treatment, maximum concentration of lead in Zea maize, Amaranthus retroflexus and Abutilon theophrasti was 686.5, 538 and 264.5 mg/Kg, respectively, while maximum cadmium concentration (36, 43, 66) was observed in Amaranthus retroflexus, Abutilon theophrasti and Zea maize. Minimum lead concentration existed in Abutilon theophrasti (15 mg/Kg) and minimum cadmium was in Zea maize (5.5 mg/Kg) which was related to ammonium phosphate treatment in the studied plants. Here is considerable amount of uptake of heavy metals such as lead and cadmium in the soil by non-edible plants (Amaranthus retroflexus and Abutilon theophrasti). Moreover, low concentration of heavy metals is observed in the soils around the industrial areas of the northern provinces of Iran. Therefore, phytoremediation technology is a fundamental step toward preserving the environment and promoting the health of the society.

Keywords: Lead, cadmium, plants, additives, phytoremediation

*Abdoliman Amouei, Department of Environmental Health Engineering, Faculty of Health, Babol University of Medical Sciences, Baol, Iran iamouei1966@gmail.com

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Saqib, Muhammad

Comparative phytoremediation potential of different halophytic grass species grown on a salt-affected field

Muhammad Saqib*, ISES UAF; Ghulam Abbas, ISES UAF; Javaid Akhtar, ISES UAF; Riaz Hussain Qureshi, ISES UAF; Muhammad Anwar ul Haq, ISES UAF

Soil salinity is a major environmental issue responsible for low yield of many crops. It is of particular importance for arid and semi arid regions of the world. About one third of the total cultivated area of Pakistan is suffering from this problem. The reclamation of these types of soils through engineering or chemical approach is neither economical nor sustainable for longer periods of time. On the other hand, the phytoremediation approach seems promising. It has been found that growing of salt tolerant grasses is not only cheaper but also profitable and long lasting practice. In order to assess their phytoremediation potential, three grass species *Leptochloa fusca, Panicum antidotale and Chloris gayana* were grown on a saline sodic soil for a period of two years. The maximum plant height and biomass was observed in the case of *Panicum antidotale* and the minimum was observed in the case of *Chloris gayana.* The better growth of *Panicum antidotale* and *Leptochloa fusca* corresponded to significant improvement in the soil properties including pH, EC_e andSAR. The reduction in these parameters was the lowest in the case of*Chloris gayana* and it was related to its poor growth. This study showed that all these three grass species were capable of growing on salt affected soil, providing fodder for animals and at the same time improving soil properties through phytoremediation.

Keywords: phytoremediation, grass, *Leptochloa fusca, Panicum antidotale and Chloris gayana*

*Muhammad Saqib, Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad, Pakistan. E-mail: drhmsab@yahoo.com; drhmsab@gmail.com

54A

Kiyawa, S.A.

Phytoremediation Potentials of *Commelina spp,* in the Semi-arid Region of Bagwai Local Government Area, Kano-Nigeria

S. A. Kiyawa*, Federal College of Education (Tech)

Levels of heavy metal concentrations in ***Commelina spp*and soil** were assessed using atomic absorption spectrophotometry. The concentration of iron (10.69 **µg/g**), copper (5.5484 **µg/g**), cobalt (4.9778**µg/g**), manganese (2.8308**µg/g**), nickel (2.6409**µg/g**) and lead (1.7053**µg/g**) were higher in the plant than in their respective soils. This shows that iron, copper, cobalt, manganese nickel and lead were most bioaccumulated by **the plant.** The highest concentration factor was observed for iron (CF≈**12**), copper (CF≈**8**), nickel (CF≈6), manganese (CF≈5), chromium (CF≈4), cobalt (CF≈4), zinc (CF≈3). The plant can therefore be considered to be an endemic indicator specie with potential for use in bioaccumulation, phytoremediation / phytoextraction as interrelationships between these metal concentrations in the soil and their tissues were significant ($p<0.05$).

Keywords: Heavy metals,*Commelina spp,* bioaccumulation, phytoremediation, semi-arid, Bagwai.

*S. A. Kiyawa, Department of Chemistry, Federal College of Education (Tech), Bichi, Kano-Nigeria

55A

Yamal, Gupta

Plasma membrane bound dehydrogenases at root surface of plants fabricate Ag-nanoparticles

Gupta Yamal*, University of Delhi; Tanuj Peddisetty, TKM College of Engineering; P. Sharmila, University of Delhi; K.S. Rao, University of Delhi; P. Pardha-Saradhi, University of Delhi

Owing to immense advantages, use of biological systems for green synthesis of Ag-nanoparticles has gained tremendous attention. Plants are known to synthesize Ag-nanoparticles endogenously in their cells. As extraction of endogenous nanoparticles for commercial application would be difficult and economically unviable, we evaluated if, plant species can generate Ag-nanoparticles exogenously. Accordingly, the root system of intact plants of various plant species were incubated in $AgNO_3$ solutions, both under sterile and non-sterile conditions. Interestingly, root system of all plant species turned clear colorless $AgNO_3$ solutions colloidal and brown, under sterile as well as non-sterile conditions. UV-Vis spectra of these colloidal solutions showed Ag-nanoparticle specific peak. Transmission electron microscopic studies confirmed presence of nanoparticles and energy dispersive X-ray analysis established that these were composed of silver. Selected area electron diffraction pattern and powder X-ray diffraction studies showed that Ag-nanoparticles were crystalline. In order to reveal mechanism associated with reduction of Ag^+ at root surface, two well established artificial electron acceptors namely DCPIP and ferricyanide (membrane impermeable) were used. Our findings unraveled that root surface possessed strong reducing capacity and we believe that this reducing strength prevailing at root surface is mediated by plasma membrane bound dehydrogenases which are responsible for reduction of Ag^+ (by guiding transport of electrons from endogenously present NADPH to exogenously present Ag^+) and exogenous fabrication of Ag-nanoparticles. Reduction mechanism at root surface appears to have been evolved by plants to counter toxic ions. Root system of intact plants can be used aptly for exogenous generation of Ag-nanoparticles.

Keywords: Ag^+, Ag-nanoparticles, dehydrogenases, exogenous synthesis

*Gupta Yamal, Department of Environmental Studies, University of Delhi, Delhi 110007, India.
yamalgupta@gmail.com

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Gawronski, Stanislaw

Polycyclic aromatic hydrocarbons fatein urban area:
Case studies in Poland and Norway

Stanislaw Gawronski*, WULS, Arne Sæbo, Bioforsk, Kajetan Dzierzanowski, WULS, Juliusz Markowski, WULS, Helena Gawronska WULS

PAHs are one of the most common pollutants in urban area, mainly of anthropogenic origin (fuel-burning, motor vehicle, asphalt production, shall gas exploration). PAHs, with some being carcinogenic and mutagenic, receive recently more attention in risk assessment of air pollution to man. Ability of 4 woody species and 2 grass to accumulate 16 PAHs were determined in Poland and Norway. Plants where cultivated in polluted (city downtown) and clean sites (nursery garden). Significant differences were found in PAHs level between counries, sites (being always higher in Poland and polluted location) as well as between tested species. PAHs removed from air by rain directly and washed off leaves are deposited in the soil. Their degradation in soil can be stimulated by vegetation and/or selected microorganisms Some grasses are known from stimulation of multiplication of microorganisms that are capable to degrade ring structure compounds Two grass species (recommended for road side cultivation) with addition of spent mushroom substrate after *Pleurotus ostreatus* cultivation, *Trichoderma harzianum* T-22 and EM (Effective Microorganisms) consortium were used for evaluation of the effectiveness of PAHs degradation. Studies are in progress and results will be presented.

Keywords: bioremediation, PAHs, *Pleurotus ostreatus, Trichoderma harzianum*, EM-microorganisms

*Stanislaw Gawronski, Warsaw University of Life Science, str. Nowoursynowska 159, 02-787 Warsaw, Poland stanislaw_gawronski@sggw.pl

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Mynepalli, Sridhar

Phytoremediation of Lead Contaminated Soils: Nigerian Experience

Sridhar Mynepall*, Universiry of Ibadan; Etaghene Johnson, University of Ibadan

Lead exposure is on the increase among the communities in Nigeria arising from waters, soils and air. A lead-acid battery industry in Ibadan, southwest Nigeria had dumped large quantities of their waste on a community's land near Olodo village several years ago. This paper describes the environmental impact of lead on the community, and the remediation of the contaminated soil using "Sunflower" (*Helianthus* sp.) with and without organic fertilization application. Field observations, focal group discussions with the community members, and analyses of samples of soil (top, subsoil and controls) and vegetation from the vicinity for lead levels were used in collecting data. The contaminated soils were acidic and red in color, with lead levels 7.706 g to 9.652 g/Kg. Vegetation and a stream nearby showed biodiversity loss. Goats and sheep grazed on the land showed deformities and abortions. Laboratory experiments revealed the following: Physical excavation was necessary to bring down the initial lead levels by about ten folds before application of chemical and phytoremediation techniques. Extraction with chemicals viz. citric acid, tartaric acid and EDTA reduced the lead levels only up to 38.7% to 61.2%. Amendment of contaminated soil with organic fertilizer at 10 to 20 tons per hectare and cultivating Sunflower was able to reduce the lead levels to the acceptable 15 to 30 mg / Kg. The plant concentrated lead in the root system more than shoot system and the seeds. The results suggest that cultivation of sunflower crop with organic fertilizer prior to growing edible crops is a feasible solution in removing lead from the affected soils.

*Sridhar Mynepall, Department of Environmental Health Sciences, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria

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Ding, Changfeng

Effects of soil type and genotype on chromium accumulation by rootstalk crops: implications for phytomanagement

Changfeng Ding*, Institute of Soil Science, Chinese Academy of Sciences; Xingxiang Wang, Institute of Soil Science, Chinese Academy of Sciences

The combination of profitable crop production with the gradual removal of soil contaminants by phytoextraction is known as phytomanagement. In the present study, the variations of chromium (Cr) accumulation in three rootstalk crop species (radish, carrot and potato) were investigated by using twelve cultivars grown in acidic Ferralsols (pH 4.8) and neutral Cambisols (pH 6.9) under two Cr treatments (112.5 and 150mg kg^{-1} for Ferralsols; 150 and 200mg kg^{-1} for Cambisols) in a pot experiment. The result showed thatboth for underground edible part and aerial part, the total Cr concentration in all cultivars grown in Cambisols was significantly higher (P<0.05) than those grown in Ferralsols. There were significant differences (P<0.05) in the total Cr uptake among different cultivars in both soils. Among the cultivars tested, radish cultivar Zhedachang consistently showed the highest total Cr uptake in both soils, being 57.6 and 92.9 μg $pot^{-1}$for Ferralsols and 251.1 and 92.7 μg pot^{-1} for Cambisols under the two Cr treatments respectively. Furthermore, the total Cr concentration in edible part of Zhedachang grown in both soils was below the National Food Hygiene Standard of China (0.5 mg kg^{-1}, fresh weight) under 150 mg kg^{-1} Cr treatment. Therefore, phytomanagement of slightly Cr-contaminated soils using rootstalk crops for food production combined with long-term phytoextraction was feasible, and radish cultivar Zhedachang was promising candidate for this approach. Continuous monitoring of Cr uptake in the edible part with the application of soil amendments is necessary to assure the food safety.

Keywords: rootstalk crops, chromium, cultivar variation, soil type, phytomanagement

*Changfeng Ding, 71 East Beijing Road, Institute of Soil Science, Chinese Academy of Sciences, Nanjing 210008, People's Republic of China cfding@issas.ac.cn

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Zaghloul, Alaa

Remediating Potential toxic Elements in sewaged soils using novel biotechnology

Mohamed Saber, Essam Hob Allah, Soad El-Ashry; Hussain Abouziena and Alaa Zaghloul*

In a completely randomized field experiment, a novel biotechnology was successively practical to remediatedPotential toxic Elements (PTE's) in a sewaged soil ecosystem. The technology was applied in two stages, first bioremediation with a biochemical remediative amendment composed of probentonite (Bentonite, rock phosphate, *Thiobacillus* sp. and phosphate dissolving bacteria) and second phytoremediation with canola, Indian mustard or black nightshade hyperaccumulator plants in association with mycorhyzea. Results indicated that the application of this novel biotechnology reduced the zinc equivalent value in the experimented sewaged soil from initially 630 to ta safe level less than 200. The effect of canola hyperaccumulator plant in general far exceeded that of the other two experimented plants; however, the differences between their efficiency were not that great. Inoculation with either mycorrhyzae (AM) or *Thiobacillus* sp. significantly enhanced PTEs uptake by the tested hyperaccumulator plants. From a kinetic prospective, the application of the combined novel biotechnology exhibited superior remediative action compared to the application it single remediative amendment in minimizing Zn equivalent value to the safe level. The different mechanisms that took place during the bioremediation process of in the studied sewaged soil were discussed.

Keywords: Bioremediation, Zn equivalent, Kinetic models, PTE's, sewaged soils.

*Alaa Zaghloul; National Research Centre, Dokki, Cairo, Egypt alaazaghloul2002@yahoo.com

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Odiwe, Anthony

Tree population, biomass and carbon stocks changes in a lowland secondary forest following a ground fire in Ile-Ife, Nigeria

Anthony Ifechukwude Odiwe*, Obafemi Awolowo University; Idris Raimi, Obafemi Awolowo University

Estimate of biomass and carbon sequestration by tree plants is important in order to determine the contribution of vegetation to global carbon (C) stocks. However, the changes in C storage in the vegetation as a function of disturbance (ground fire) in forest ecosystems remain poorly understood. This study examined the impact of a ground fire on aboveground, belowground biomass and carbon sequestration potential of a secondary lowland forest in Ile-Ife, Southwest Nigeria. Results showed that the stem density decreased significantly ($p \leq 0.001$) from 392 tree ha^{-1} one year to 2456 trees ha^{-1} 14 years after. Basal area and species diversity increased during the period. Aboveground biomass decreased from 14.09 t ha^{-1} (before fire) to 7.89 t ha^{-1} (one year after) and increased to 12.37 t ha^{-1} (14 years after). The belowground biomass also decreased from 3.66 t ha^{-1} (a year after) to 2.05 (before the fire) and increased to 3.22 t ha^{-1} 14 years after the fire. The total biomass ranged from 9.94 t ha^{-1} (one year after) to 17.75 t ha^{-1} (before fire). The total carbon accumulated in the forest before the fire, 7.05 t C ha^{-1} got reduced to 4.97 t C ha^{-1} a year after while the forest has recovered from the fire with a value of 7.79 t C ha^{-1} 14 years after. It is clear that disturbance influenced the biomass and carbon stock negatively and the recovery over the years might indicate that the carbon sink can be increased with minimal disturbances.

Keywords: biomass, carbon stock, fire, forest, secondary forest

***Anthony Odiwe, Department of Botany, Obafemi Awolowo University, Ile-Ife BC220005, Nigeria. aiodiwe@oauife**

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Valderrama, Aly.

Classic and Enhanced-EDTA water phytoremediation by *Azolla filiculoides* on hydroponic conditions

Aly Valderrama*, Universidad de Talca; Danny E. Carvajal, Universidad de La Serena

Phytoremediation was definedas the use ofgreen plantsto removepollutantsfrom the environmentorrender them harmless. On this research wasproposed the use ofethylenediaminetetraacetic acid (EDTA)as a ligandof Cdand Cuto transform at the complex ions shape, which under optimalpH conditionscan be absorbedmore efficientlythan thepureion formforthe species*Azollafiliculoides* on hydroponic conditions. The metal concentrations accumulated by *Azolla*were measured byatomic absorptionspectroscopyand the physiological response was measured by the photosynthetic efficiency by Fv/Fm factor. We evaluatedthe capabilitiesof*A.filiculoides*to accumulatecadmiumand copper, being exposed toclassicphytoremediation. Result thatcadmiumaccumulatedfrom 12.90 - 1623.20 $\mu g g^{-1}$of Cdand in the caseof copperaccumulatedfrom8.97 - 6013.05$\mu g g^{-1}$of Cu. The enhanced phytoremediationwithEDTA, obtained variable results.For Cd-EDTA exposureof *A.filiculoides* accumulated 3.35 - 93.11$\mu g\ g^{-1}$ of Cd andwhen exposedto Cu-EDTA accumulated500.59 - 1169.45 $\mu g g^{-1}$of Cu. The photosynthetic efficiencyinclassiccadmiumphytoremediationrangedbetween0.803 - 0.702, and for coppervariedbetween0.803 - 0.772. However forEDTA enhanced phytoremediation, the Fv/Fmwas between0.717 - 0.633for Cd-EDTA andCu-EDTA varied between0.717 - 0.618. The enhanced phytoremediationwith EDTAwas able to increasethe accumulation ofCu-EDTA complexwhen the concentrationdid not exceed2.5 $mg L^{-1}$complexand theCd-EDTA complexwas unable to overcomethe thresholdsachieved withclassicalphytoremediation.

Keywords: Phytoremediation, heavy metals, Azollaceae, EDTA, atomic absorption spectroscopy.

*Aly Valderrama, Universidad Nacional Autónoma de México, Centro de Investigaciones en Ecosistemas, Campus Morelia, México. avalderrama@cieco.unam.mx

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Anjum, Naser A.

Cross-talks on non-biological and biological strategies underlying two salt marsh macrophytes responses to environmental mercury exposure

Naser A. Anjum*, University of Aveiro; Iqbal Ahmad, University of Aveiro; Armando C. Duarte, University of Aveiro; Eduarda Pereira, University of Aveiro

The physiological/biochemical or chemical characterization of plant responses to metal-metalloid-exposure has been accepted as a representative basic step towards: (a) revealing plants' tolerance/adaptive potential to metal-metalloid-contaminated conditions and, (b) for environmental contaminants' remediation potential affirmation as well. To this end, at reference and the sites with highest, moderate and the lowest mercury-contamination within historically Hg-contaminated Ria de Aveiro coastal lagoon (Portugal), the present study investigates basic non-biological and biological strategies underlying salt marsh macrophytes *Juncus maritimus* and *Halimione portulacoides* differential mercury accumulation and tolerance potential. On the perspective of the results of non-biological strategy adoption by *J. maritimus* and *H. portulacoides*, the physico-chemical properties of sediment especially the sediment-redox potential was influenced differentially by the *J. maritums* and *H. portulacoides* vegetation and seasonal changes as well, which in turn, influenced the chemistry of sediments; thus, previous factors cumulatively influenced the bioavailability of mercury and the mercury-retention capacity of both salt marsh sediments and salt marsh macrophytes. To the biological or physiological/biochemical strategy adoption, corresponding to the mercury-burdens at different sites and irrespective of salt marsh macrophytes, the studies organs (roots and leaves) exhibited differential damage and defense endpoints and polypeptide pattern-modulation. Root and leaf adopted differential osmotic-adjustment strategy contingent to mercury-burden. This deliberation will present largely ignored: (a) critical cross-talks on the success and failure of both non-biological and biological vital mechanism adopted by organs and their substantiation with organ-specific polypeptide patterns in *J. maritimus* and *H. portulacoides*.

Keywords: Mercury, salt marsh, macrophytes, responses, mechanisms

*Naser A. Anjum, CESAM-Centre for Environmental and Marine Studies & Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal. anjum@ua.pt

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Zalesny, Ron

A Review of Ecosystem Services Associated with Using *Populus* for Phytotechnologies

Ronald S. Zalesny Jr.*, U.S. Forest Service, Northern Research Station

Populus species and hybrids are among the most-studied trees in the world. Decades of research and development have resulted in breeding and identifying genotypes that are tailored to specific end uses, including phytotechnologies. These purpose-grown feedstock production systems provide *regulating* (e.g., erosion control and soil quality), *provisioning* (e.g., biomass and freshwater), *cultural* (e.g., spiritual and educational), and *supporting* (e.g., nitrogen and water cycles) ecosystem services as outlined in the Millenium Ecosystem Assessment. While integral to most applications, the direct focus on these services is often overlooked relative to specific research objectives (e.g., measuring uptake of contaminants into tree tissues, assessing cycling of soil nutrients following wastewater application, etc.). Given the recent development of the database of North American *Populus* research conducted from 1989 to 2011 (Zalesny and Coyle, 2013; www.poplardatabase.com), I am synthesizing the ecosystem services contained within the 125 unique phytotechnology-related studies reported in the peer-reviewed literature included in the database. In addition to the specific services, my synthesis will include relevant silvicultural information such as the genomic groups, clones, contaminants, and soil properties tested. My presentation will focus on assessing the advantages and trade-offs of these systems, especially with regard to the direct connection to multiple end-uses that benefit society.

Keywords: biomass, hybrid poplar, Millennium Ecosystem Assessment, poplar database

*Ronald S. Zalesny, Institute for Applied Ecosystem Studies, 5985 Highway K, Rhinelander, WI 54501, USA; rzalesny@fs.fed.us

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Zalesny, Ron

Using Phyto-Recurrent Selection to Identify Favorable *Populus* Genotypes Grown in Biochar-Amended Soils

Ronald S. Zalesny Jr.*, U.S. Forest Service, Northern Research Station; William L. Headlee, Iowa State University; Deborah S. Page-Dumroese, U.S. Forest Service, Rocky Mountain Research Station

Biochar is a value-added byproduct of the bioenergy industry that contributes to sustainability of the energy supply chain. Headlee et al. (2013) reported that biochar provided similar benefits to hybrid *Populus* clone 'NM6' in terms of nutrient availability and growth when substituted for vermiculite in greenhouse production. We are currently using phyto-recurrent selection to choose *Populus* clones that exhibit greater survival and growth when grown in biochar-amended soils versus those containing vermiculite or no soil amendments. Using three phyto-recurrent selection cycles, we have reduced a base population of 61 genotypes (cycle 1) to 30 (cycle 2) in the greenhouse, and will be advancing 10 clones to field testing during cycle 3. Our specific objectives are to test for differences among: 1) soil treatments (100% peat, 75% peat + 25% vermiculite, 75% peat + 25% biochar) for chemical properties (pH, CEC, ECEC) and nutrient content (total N, P, and exchangeable K, Ca, Mg, and Na), 2) *Populus* genotypes for survival, growth and biomass, and uptake of nutrients (N, P, K, Ca, Mg, Na) into roots, stems, leaves, and cuttings, and 3) their interactions. To date, we have completed cycle 1 and have used a multiplicative rank summation index (based on weighted allometric traits and survival) to identify the top 30 genotypes to advance to cycle 2 during spring 2013. Cycles 2 and 3 will be completed in summer 2013 and results for all objectives will be presented.

Keywords: biomass and bioenergy, clonal selection, hybrid poplar, plant propagation, plant uptake

*Ronald S. Zalensy, Institute for Applied Ecosystem Studies, 5985 Highway K, Rhinelander, WI 54501, USA; rzalesny@fs.fed.us

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Zalesny, Ron

Growth, Biomass Productivity, and Aboveground Carbon Storage of Poplar at Long-term Phytotechnology Installations

Ronald S. Zalesny Jr.*, U.S. Forest Service, Northern Research Station; William L. Headlee, Iowa State University; Gayathri Gopalakrishnan, Space Science Institute; Richard B. Hall, Iowa State University; Dennis W. Hazel, North Carolina State University; J.G. Isebrands, Environmental Forestry Consultants; M. Cristina Negri, Argonne National Laboratory; Elizabeth Guthrie Nichols, North Carolina State University; Donald L. Rockwood, University of Florida

Given their fast growth, extensive root systems, and elevated water usage, short rotation woody crops (SRWCs) are ideal for incorporating intensive forestry with waste management and other environmental remediation systems. *Populus* species and their hybrids are among those SRWCs that have been successfully used for numerous phytotechnology applications. In addition to the traits above, the inherent genetic variability within *Populus* allows for selection of superior clonal material based on genetic- and site-related factors, as well as how specific genotypes respond to such stimuli. While there is substantial reported information during stand establishment, one of the most challenging aspects for tree improvement programs is the ability to continue measurements and monitoring throughout the rotation. This is also a major concern at phytoremediation sites. Therefore, the objective of the current study was to re-visit key phytotechnology installations in the Midwest (Illinois, Iowa, Wisconsin) and Southeastern United States (Florida, North Carolina) to evaluate long-term survival and growth of *Populus* genotypes belonging to a broad range of genomic groups. Survival and diameter will be compared at each site, and biomass will be estimated to project potential feedstock supplies for the bioenergy industry and aboveground carbon storage potential for ecological sustainability. Particular emphasis will be placed on genotype selection based on contaminants and site factors (i.e., soils and climate).

Keywords: biomass, clonal selection, diameter at breast height, field tests, *Populus*

*Ronald S. Zalensy, Institute for Applied Ecosystem Studies, 5985 Highway K, Rhinelander, WI 54501, USA; rzalesny@fs.fed.us

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Chapungu, Lazarus

Effectiveness of Water Hyacinth *(Eichhornia Crassipes)* in Remediating Polluted Water: The Case of Shagashe River in Masvingo, Zimbabwe

Lazarus Chapungu*, Great Zimbabwe University, Phanankosi Moyo, Great Zimbabwe University; Boyceen Mudzengi, Great Zimbabwe University

Dumping of raw sewer into fresh water bodies has become common practise of municipalities in Zimbabwe. This has significantly contributed to the proliferation of water hyacinth *(Eichhornia Crassipes)*which is widely regarded as subversive to aquatic ecosystems. The weed, while a threat to the aquatic ecosystems, this study explored it's effectiveness in remediating sewage polluted water along Shagashe River in Masvingo province. Triplicate samples were collected on three different points designated SR1, SR2 and SR3 along the river. The course of the river stretching from SR1 to SR3 was covered by over 95% water hyacinth during the period of study. SR1 was located on the upper stream, SR2 centrally and SR3 furthest downstream. Analysis for electrical conductivity, total dissolved solids (TDS), sulphates, phosphates, total hardness, pH, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates, nitrites and total nitrogen on all samples was done. The parameters were statistically analysed to assess whether there was any significant reduction moving downstream. The results indicate that water hyacinth was remediating the river as noted by the significant reduction of electrical conductivity (25% decrease), total dissolved solids (TDS) (26%), sulphates (45%), phosphates (33%) and total hardness (37%) between the sample points SR1 and SR3. Statistical analysis showed no significant changes for the other parameters.

Keywords: Water hyacinth, bioremediation, physico-chemical parameters, pollution, phytoremediation

*Chapungu Lazarus, Great Zimbabwe University, P.O. Box 1235, Masvingo, Zimbabwe
lchapungu@gmail.com

Govindwar, Sanjay

Evaluation of plants' potential for the development of phytoremediation technologies for removal of dyes from textile effluent

Sanjay Govindwar*, SUK India; Rahul Khandare, SUK; Akhil Kabra, SUK; Jyoti Jadhav, SUK

Phytoremediation is an emerging technology for the clean up of contaminated sites which involves the use of plants and their rhizospheric microorganisms for the removal of pollutants. Dyes, which are primary constituents of the waste from the textile industry effluents, constitute a group of recalcitrant compounds, many of which are known to have toxic, mutagenic and carcinogenic effects. The study of the potential and mechanisms adopted by the plants (*Blumea malcolmii*, *Tagetes patula*, *Typhonium flagelliforme*, *Aster amellus*, *Portulaca grandiflora,Petunia grandiflora, Zinnia angustifolia* and *Glandularia pulchella)* with respect to the effect of physicochemical parameters, nature and role of oxidoreductive (biotransforming) enzymes, and redox potentials in the removal of various textile dyes (Direct Red 5B, Brilliant Blue R, Remazol Red, Green HE4B and Remazol Orange 3R) helps in broadening the horizons of phytoremediation technologies. The use of *in vitro* cultures viz. hairy roots, suspensions, calli and whole plants helps to know the enzymatic status, the products of metabolism of dyes, and convince direct plants' involvement providing a new dimension to phytoremediation studies. Various plants, alone or in combination with other plants or microorganisms growing on its exudates combine the advantages of both plant and microbial systems for enhanced dye degradation in laboratory scale phytoreactors. Toxicity testing of treated textile effluents provides reusability of water for agricultural purposes. The ultimate aim of phytoremediation involves the application of these well studied plant systems at the contaminated sites which may constitute the development of constructed wetlands for on-site treatment of textile industrial effluents.

Keywords: phytoremediation, textile effluents, decolorization, detoxification, phytoreactors

* Sanjay Govindwar, Department of Biochemistry, Shivaji University, Kolhapur-416004, Maharashtra, INDIA spg_biochem@unishivaji.ac.in

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Nwaichi, E. O., Monano, M. O. and Nwoha, P. A.

Remediation of Cadmium and Lead- Contaminated Wetland by *Hevea brasillensis*

E.O. Nwaichi*, Monano, M. O. and Nwoha, P. A., University of Port Harcourt, Port Harcourt, P. M. B.

The present investigation provides data on *Hevea brasilliensis'* performance at site clean - up. Effluent sample from a wetland around an abandoned well site in Mgbuoba, a Nigerian Niger Delta community was characterized prior to a 43d hydroponic experiment, using *H. Brasilliensis* in the presence of white light and salted regime to assess its performance at contaminant removal. Deionized water was used as control and all experiment was done in triplicates. Observed levels of studied heavy metals (Cd, Pb, and Fe) were statistically significant at $p \leq 0.05$ and were reduced to 61.1%, 50.5% and 41.6%) respectively. Salt treatment gave greater removal efficieny and were up to 90.7%, 82.2% and 67.9% respectively. Generally, results indicate excellent levels of extraction of contaminants leaving relatively low or non – detectable values, and thus present *H.brassilliensis* a candidate for phytoremediation of oil-related contaminated liquid effluent especially a salt – assisted design.

Keywords: oil - related effluent, heavy metals removal, *Hevea brasiliensis*, hydroponic, salt enhancement

* E.O. Nwaichi, 5323 Port Harcourt, Rivers State, Nigeria nodullm@yahoo.com

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Sridhar K.B, Jhansi

To Study the Influence of Lead and Nickel on Pptake and Retention by Different Tree Species in a Pot Culture Experiment using Two Type of Soils.

Jhansi Sridhar K.B,* NRCAF .Avudainayagam. S, TNAU Coimbatore, Veeramani FCRI, Mettupalayam, K., Ramesha M.N., CSWRTI, Datia, Dhyani S.K NRCAF.Jhansi, Rajendra Prasad NRCAF,Jhansi., Tewary R.K NRCAF, Jhansi, Gurunathan N., NRCAF, Jhansi

The term heavy metal generally refers to a specific group of elements with metallic properties often associated with contamination and potential toxicity or ecotoxicity. A few plant species are able to survive and reproduce on soils heavily contaminated with heavy metals.
Phytoremediation is used for the removal of pollutants from both soil and water. Some of the ornamental trees which have aesthetic effect and tolerant to pollution have been screened and recommended for planting along the roads like Ficus (*Ficus religiosa*), Bergard (*Ficus bengalensis*), Neem (*Azardirachta indica*), Arjun (*Terminalia arjuna*), Teak (*Tectona grandis*) etc.
An experiment was conducted to know the uptake and retention of heavy metals by using five tree species in a pot culture experiment which was laid out in a factorial completely randomized design with seven levels of heavy metals as treatments T_1 – control, T_2 - Ni - 50 mg/kg, T_3 - Ni - 75 mg/kg, T_4 - Ni -100 mg/kg and T_5 - Pb - 100 mg/kg, T_6 - 125 Pb - 125 mg/kg, T_7 - Pb - 250 mg/kg. The observations were carried out at monthly interval up to 4 months. The accumulation was found to be greater in sandy loam soils while it was less in clay loam soils. Both the metals showed similar effect on accumulation in the earlier stages, while in the later stages they showed greater variation. However the accumulation was found in the order roots > stem > leaves. Over all the metal accumulation was more in *Delonix regia* (28.32 mg/kg), followed by *Pongamia pinnata* (19.73 mg/kg) and *Leucaena leucocephala* (16.22 mg/kg). Among the heavy metals, Ni was found accumulated more when compared to lead. The maximum retention of heavy metals was observed in Ni in clay loam soil at all the intervals 115.39, 117.03 and 140.08 mg/kg while in sandy loam it was less 54.89, 50.43 and 70.43 mg/kg. However *Deloniox regia* (57.23 mg/kg) and *Pongamia pinnata* (63.94) recorded lowest retention of heavy metal in case of both the soils.

Keywords: heavy metal, phytoremediation, soil, accumulation, contamination

* Jhansi Sridhar K.B., National Research Center For Agroforestry, ICAR, Jhansi, India. sriaranya@gmail.com.

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Chigbo, Chibuike

Phytoremediation Potential of *B. juncea* in Cu-pyrene co-contaminated soil: Comparing Freshly Spiked Soil with Aged Soil

Chibuike Chigbo*, University of Birmingham; Lesley Batty, University of Birmingham

A comparison was made between the dissipation of pyrene as well as the uptake of copper (Cu) in soil freshly spiked with Cu, pyrene or Cu+ pyrene and in aged soil. The potential of *B juncea* for phytoremediation was also investigated.

The biomass of *B. juncea* significantly decreased (> 50% reduction) in freshly spiked soil when compared to aged soil in all treatments. However, the accumulation of Cu in shoot was significantly reduced (60-88% reduction) in aged soil after 60 days of planting. The total removal of Cu from co-contaminated soil was always higher (> 2-3 fold) in aged soil than in freshly spiked soil when lower Cu concentration ($50 mg.kg^{-1}$) was co- contaminated with 250 or $500 mg.kg^{-1}$ of pyrene while in other co-contaminated treatments, the total removal of Cu from aged soil was significantly less.

The level of pyrene in both planted and unplanted soil for freshly spiked soil decreased significantly (>67 % reduction) over the 60 days on plant trial. However, in aged soil, there was no significant difference in residual pyrene concentration between planted and unplanted soil. This suggests that the presence of *B. juncea* in aged soil did not enhance the dissipation of pyrene and that the prediction of pyrene dissipation in laboratory prepared soil may not have reflected the true situation in the fields.

Keywords: Cu; Pyrene; *B. juncea*: dissipation

* Chibuike Chigbo, University of Birmingham, UK. Coc045@bham.ac.uk

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Basumatary, Budhadev

Phytoremediation of Hydrocarbon and Heavy Metal using *Cyperus rotundus* (Linn.)in Petroleum Sludge Contaminated Field

Budhadev Basumatary*, Institute of Advanced Study in Science and Technology, Hamendra Chandra Das,Centre of Excellence for Energy Studies, Oil India Limited, Sabitry Bordoloi, Institute of Advanced Study in Science and Technology

Phytoremediation technique developed in laboratory condition was tried in the petroleum sludge dumped area (100 × 100 m) in oil field of Duliajan, Assam, India. After bioremediation the field still contained residual amount (65,000 to 75,000 mg. kg^{-1}) of total petroleum hydrocarbon (TPH) concentration. *Cyperus rotundus* (Linn.) was planted during 2010 and continuously monitored for TPH concentration in soil, and accumulation in plant tissue in subsequent years till December, 2012. The area was properly fenced to protect from external agents. Hydrocarbon and heavy metal concentration in plant tissues were carried out at an interval of 2 months. Plant growth performance and biomass production in the hydrocarbon contaminated field was higher during the summer period in comparison to winter period in the field condition. Along with TPH degradation in soil and accumulation in plant tissues, this plant species showed accumulation of Cr, Pb, Cd, Fe, Zn, Cu and Ni in field conditions as was observed in laboratory study with this plant species. Concerning TPH degradation, about 90% of measurable TPH was degraded during the study period. Accumulation of hydrocarbon in roots and shoots was significant. Changes were observed in soil physico-chemical characteristics during the study period. Enumeration of population of hydrocarbon-degrading microorganisms suggests that biodegradation may be affected by plant microbe interaction in the rhizosphere region. The present study revealed that this species is effective in degradation of hydrocarbon in root zone as well as through accumulation in plant tissues of heavy metal and TPH in the present ecological condition.

Keywords: accumulation, *Cyperus rotundus*, heavy metal, hydrocarbon

* Budhadev Basumatary, IASST, Guwahati – 781 035, India. budhabasumatary@yahoo.com

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Sahay, Seema

Metal Tolerance and its Remediation by Oil Yielding Crop *Brassica juncea* (cv. Pusa bold) Grown on Soil Amended with Flyash and Irrigated with Wastewater

Seema Sahay*, Aligarh Muslim University, Akhtar Inam,Arif Inam, Saba Iqbal, Aligarh Muslim University, Hamid Iqbal Tak, North-West University

The two waste products, flyash (FA) from thermal power plant and wastewater (WW) generated from urban population has assumed a big and important dimension in many countries including India. Harduaganj thermal power plant is source of flyash in Aligarh, famous for lock and nickel planting industries discharge huge amount of wastewater rich in heavy metals. Today both wastes have become an alternative source of chemical fertilizers for local farmers. In this paper, their utilization is discussed on the basis of results obtained in a pot experiment conducted in Botany department, while observing the growth, yield and nickel uptake of *Brassica juncea* (cv. Pusa bold). The experiment was run with two levels of FA @ 10 and 20 t/ha and three doses of NPK @ 40:15:15, 60:30:30 and 80:45:45 kg/ha. Results showed that drymatter yield, seed yield and oil content of the crop tested was increased in both $FA_{10}WW$ and $FA_{20}WW$ as compared to crop grown under GW treatments and control having no FA, WW and NPK. The nickel uptake and translocation factor (Tf) showed the successive potential of Ni tolerance of *Brassica juncea* in soil amended with FA and irrigated with WW. The Tf was higher in FA+WW treatments than FA+GW and control. The overall results indicated that $FA_{20}N_{40}P_{15}K_{15}$ was found to be most suitable combination with assessment of yield and high oil content as well as Ni accumulation in plant parts. Therefore both wastes may compensate the fertilizers consumption and in addition be an alternative option of their disposal.

Keywords: Indian mustard, soil fertility, phytoremediation, oil content, waste byproducts

* Seema Sahay, Plant Physiology and Environmental Section, Botany Department, Aligarh Muslim University, Aligarh, India. sahayseema47@gmail.com

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Sapci, Zehra

Elemental Move in Intermitted Aquatic Phases: Water, Pore Water and Sediment, and from the Phases to Benthic Plant

Zehra Sapci*,Yildiz Technical University, Bitlis Eren University

The objectives of this experimental study were to examine the element move in three phases; water, pore water and sediment structure in contaminated aquatic environments, and element uptake by benthic plant from one environment. As benthic plant, *Myriophyllum verticillatum* were investigated in the study. Fe, Cr, Zn, Ni and Cu concentrations in the aquatic phases and in the plant body were researched in laboratory condition.

Following the analyses, it was observed that the amount of the metals in each of the phases in the environments was different for each intermittent sample. Following the metal analyses, it was found that the concentration of Fe, Cr, and Zn in the effluent water was found to be greater than that in the influent water. These metal concentrations in the effluent sediment was measured to be less than in the influent sediment. It can be concluded that these metals probably bounded poorly to the sediment and transfer from the sediment to the pore water and then to the water or the plant body. Studies with *M. verticillatum* demonstrated that the concentration of all of the elements in the plants was changing relatively. The Zn and Cu levels in the combination of the leaves and stems were found to be significantly higher than the levels in the roots at the end of the trial.

Keywords: *Myriophyllum verticillatum*, metal, water, pore water, sediment.

* Zehra Sapci, Bitlis Eren University, Environmental Engineering Dept. Bitlis, Turkey
zsapci@beu.edu.tr

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Favas, Paulo

Uranium Accumulation by Spontaneous Aquatic Plants from a Uraniferous Region (NE Portugal)

Paulo J.C. Favas*, University of Trás-os-Montes e Alto Douro*, Cristina Cordeiro, University of Trás-os-Montes e Alto Douro, João Pratas, University of Coimbra

The main objective of this study was to evaluate the accumulation of uranium (U) in spontaneous aquatic plants from the uraniferous region of Horta da Vilariça (Northeast of Portugal). For this purpose were selected 15 sites for sampling of water, sediments and aquatic plants representative of the aquatic flora of the region. For the detection of U in water, sediment and plants was used the method of fluorimetry. The concentration of U in water ranges from 0.6 µg/L to 5.56 µg/L, with a mean of 1.98 µg/L. The concentration of U in sediments ranges from 123.5 µg/kg to 23,909.5 µg/kg with a mean of 3,929.2 µg/kg. In the sampling points were collected 26 species of aquatic plants totalizing 199 samples. Plants that have higher content of U (mean) are *Scorpiurium deflexifolium* (34,205.0 µg/kg), *Fontinalis antipyretica* (25,612.4 µg/kg), *Nasturtium officinale* (roots) (7,380.1 µg/kg) and *Roripa sylvestris* (aerial parts) (7,280.5 µg/kg). However, the remaining plants also exhibit the ability to concentrate U. The species *Roripa sylvestris* has a higher mean content of U in the aerial parts over the roots, which shows ability to translocation and bioaccumulation. The highest values of the bioconcentration factor (BCF = concentration of U in plant / concentration of U in water) are: 2.4×10^4 for *Scorpiurium deflexifolium*; 1.6×10^4 for *Fontinalis antipyretica*; 5.1×10^3 for *Nasturtium officinale* (roots); and 4.3×10^3 for *Roripa sylvestris* (aerial parts). Therefore, the spontaneous local species have some ability to concentrate U in their tissues, highlighted by the high U bioaccumulated contents and the BCF values.

Keywords: phytofiltration, bioaccumulation,Horta da Vilariça, uranium deposit

* Paulo J.C. Favas, School of Life Sciences and the Environment, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal; IMAR-CMA Marine and Environmental Research Centre, University of Coimbra; pjcf@utad.pt

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Favas, Paulo

Assessment for Phytoremediation of Flora Tolerant to Heavy Metals in the Contaminated Soils of an Abandoned Lead Mine

Paulo J.C. Favas, University of Trás-os-Montes e Alto Douro*, João Pratas, University of Coimbra, Rohan D'Souza, St. John's College, Mayank Varun, St. John's College, Manoj S. Paul, St. John's College

Significant accumulation of heavy metals in soils and native wild flora suggests that metal contamination especially that of Pb (up to 9,330 mg/kg) is a matter of great concern in the Barbadalhos mine (or Zorro mine) area, in Central Portugal. The native flora displayed its ability to withstand high concentrations of heavy metals in the soil. However, accumulation patterns of metals in the plants tested differed. Although they accumulated Pb, Zn, Fe and Cu, they displayed limitations in mobilizing Ag, Co, Cr, and Ni from the soil for subsequent uptake. As metal concentrations in above ground parts were maintained at low levels, metal tolerance in most cases may mainly depend on their metal excluding ability. However, metal concentrations higher than toxic level in some species like *Cistus salvifolius* (for Pb); *Digitalis purpurea* (for Pb, Zn, and Fe), *Lonicera periclymenum*, *Anarrhinum bellidifolium* and *Phytolacca americana* (for Pb and Zn); *Andryala integrifolia* and *Ruscus aculeatus* (for Fe); as well as *Mentha suavolens* and *Rubus ulmifolius* (for Ag) indicate that internal detoxification metal tolerance mechanisms might also exist; therefore, their utility for phytoremediation is possible. Furthermore, the plants could grow and propagate in substrata with low nutrient conditions which would be a great advantage in the revegetation of mine tailings. It was also observed that despite lower accumulation, trees of the region can be very effective due to their higher biomass.

Keywords: phytoextraction, bioaccumulation,Barbadalhos mine, Zorro mine, metal-tolerant plant

* Paulo J.C. Favas, School of Life Sciences and the Environment, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal; IMAR-CMA Marine and Environmental Research Centre, University of Coimbrapjcf@utad.pt

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Favas, Paulo

Uptake of Gold, Silver, Antimony and Arsenic by Water Mosses

Paulo J.C. Favas*, University of Trás-os-Montes e Alto Douro, Filipe Pratas, University of Coimbra, Jorge Canhoto, University of Coimbra, João Pratas, University of Coimbra

We tested the ability of two species of water mosses in the uptake and accumulation of the elements Au, Ag, Sb and As in aqueous solution. *Fontinalis antipyretica* and *Fontinalis squamosa* are water mosses growing underwater in small water courses. Stems of both species were collected in a stream in the centre region of Portugal and brought to the laboratory where attempts to obtain aseptic cultures were performed. Thus were established *in vitro* cultures of these species and determined the most favorable conditions for its cultivation. Once enough plant material was obtained we have tested the ability of both species to growth in the presence of Au added to the growth medium as sodium tetrachloroaurate (III) hydrate ($NaAuCl_4$) in concentrations ranging from 0.5 to 20 μM. The results indicated that *Fontinalis antipyretica* showed a growth rate similar to the control on media containing until 3.75 μM. Higher concentrations impaired plant growth. *Fontinalis squamosa* showed better adaptation to higher concentrations. We also made similar studies with Ag, Sb and As with the same concentrations range. Experiments made in aquarium over 30 days tested the accumulation behavior of the plants in the presence of gold iodide (AuI), gold cyanide (AuCN), sodium tetrachloroaurate (III) hydrate ($NaAuCl_4$), antimonium tartaricum ($C_4H_4O_7Sb.Na$), arsenic trioxide (As_2O_3) and silver nitrate ($AgNO_3$) in three different concentrations.*Fontinalis antipyretica* showed morphological changes at concentrations above 1.25μM of As, and above 3.75μM of Au and Ag and unchanged for Sb. Morphological changes were pronounced at 5 and 20μM of As, at 5μM of Au and at 20μM of Ag, and there is the highest levels of toxicity with marked necrosis on all explants. For the specific case of 20μM of As was clearly visible to the fact that high levels of toxicity is associated with the formation of a greater number of buds, suggesting an attempt to plant expansion in other directions with improved growth conditions.The results obtained with GF-AAS (Graphite Furnace Atomic Absorption Spectrometry) technique seem to indicate that both plants are suitable biosorbents for Au, Ag and Sb. Better results were obtained with iodide solution.

Keywords: *Fontinalis antipyretica* Hedw, *Fontinalis squamosa* Hedw, bioaccumulation, phytofiltration, *in vitro* cultures

* Paulo J.C. Favas, School of Life Sciences and the Environment, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal; IMAR-CMA Marine and Environmental Research Centre, University of Coimbra pjcf@utad.pt

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Hunter, James

Colum Study Investigation of Constructed Wetland Media Type for Treatment of Slag Leachate

James G. Hunter*, Morgan State University; Dong Hee Kang, Morgan State University

Air-cooled blast furnace slag (BFS) used in the highway environment leads to problematic leachate under poor drainage conditions. The leachate is a source of high pH, sulfur, and dissolved solids. A column experiment was designed to evaluate the treatment of BFS leachate by media commonly used in passive treatment systems. The treatment efficiency of columns was assessed using inorganic (gravel and limestone) and organic (peat and mushroom compost) media. Also, the affect of zero-valent iron (ZVI) was evaluated. Columns were dosed with experimentally generated BFS leachate and operated under residence times of 7 and 14 days. The column depths of 45 cm and 75 cm allowed for determination of the role of anoxic conditions in the transformation, precipitation, and adsorption of dissolved constituents. The organic treatments were more effective for reducing pH, TDS, sulfate, and total sulfur. Mushroom compost, with ZVI and a residence time of 14 days, was the most effective matrix for the removal of sulfate (67%), and total sulfur (72%). Peat treatments resulted in the lowest pH at 6.34; however, concentrations of Al, Ba, Fe, Mg, and Mn were elevated. Organic biofilters utilizing sulfate-reducing bacteria (SRB) and ZVI may prove to be useful for treating BFS leachate and other sources of sulfur and TDS pollution.

Keywords: wetland, blast furnace slag, sulfur, zero-valent iron

* James G. Hunter, 1700 E. Cold Spring Lane, Baltimore, MD james.hunter@morgan.edu

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Hunter, James

Greenhouse Evaluation of Plant-based Treatment for Slag Leachate

James G. Hunter*, Morgan State University; Dong Hee Kang, Morgan State University

A greenhouse experiment using combinations of gravel, limestone, organic peat, and *Scripus validus* (soft stem bulrush) was designed to assess the treatment efficacy for treating leachate released from air-cooled blast furnace slag (BFS). Generated leachate under reduced conditions, it is a source of high pH, sulfur, dissolved solids, as well as metals trapped in fine mineral particles and calcite precipitates. Wetland mesocosms with gravel as the support media were evaluated using the following variations: unplanted; *Scripus* only; 10 % limestone; *Scripus* and 10% limestone; peat only; peat and *Scripus*; and peat, *Scirpus* and limestone. The mesocosms were operated under residence times of 7 and 14-days. Results indicate that treatments with peat were more effective at lowering pH and dissolved solids. However, concentrations of metals, Al, Ba, Fe, Mg, and Mn, were elevated due to increases in solubility as a result of peat's acidic properties. Peat treatments also were the most effective matrix for the removal of sulfate (up to 25%), and total sulfur (37%). Lastly, the use of wetland plants lowered pH, but also increased solubility of metals. Macrophytes have the ability to transport and leak oxygen to the root zone thus oxidizing sulfur species, resulting in increased sulfate concentrations.

Keywords: slag, sulfur, leachate, bulrush

* James G. Hunter, 1700 E. Cold Spring Lane, Baltimore, MD james.hunter@morgan.edu

Moyo, Phanankosi

A Proposed Integrated Management Approach To The Control Of Water Hyacinth *(Eichhornia crassipes)*: The Case Of Shagashe River In Masvingo, Zimbabwe

Phanankosi Moyo*, Great Zimbabwe University, Lazarus Chapungu, Great Zimbabwe University, Boycen Mudzengi, Great Zimbabwe University

Water hyacinth invasion has become a global challenge which has had detrimental impacts on ecosystems and economies. The water weed has spread to most water bodies across Zimbabwe, including Shagashe River, where it has caused a multitude of problems economically, socially and environmentally. A number of control strategies have been tried in various countries but with limited success. In this paper, an integrated management approach is proposed. The approach entails strategically timing removal activities and processes to take advantage of prevailing environmental conditions. This involves the manual removal of remnants during rainy season flooding which removes a significant mass of the plant. Beetles reared locally can also be released on the remnant plants to ensure constant suppression. Artificial wetlands can be constructed to reclaim the river by significantly reducing the concentration of nutrients. Diversion wetlands can be set up- stream where water from the river would be channelled to pass through the constructed wetlands and treated before it flows back gravitationally into the river's main course. Waste coming from sewer treatment plants can too be channelled to pass through the constructed wetlands for further treatment. In-stream wetlands made using artificial floating islands placed on different points of the river with weir dams can be used for further *in situ* water treatment. The strategically timed and continuous removal and suppression of water hyacinth and starving it of nutrients will contribute significantly to the reduction in its proliferation.

Keywords: wetlands, nitrates, phosphates, water hyacinth, phytoremediation

*Moyo Phanankosi, Great Zimbabwe University, P.O. Box 1235, Masvingo, Zimbabwe
pha.moyo@yahoo.co.uk

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Coletta, James

Selection of Native vs. Ornamental Plants for Bioretention Applications

James Coletta*, Michigan State University

Stormwater runoff poses many environmental concerns that can be mitigated by the installation of bioretention basins. These systems function to infiltrate stormwater runoff and capture common pollutants from urban environments. Research has shown that vegetation provides filtration and retention of stormwater runoff pollutants. Plant lists for bioretention have been created throughout the Great Lakes Region. These plant lists promote the use of native plants and not plants that are typically available in landscape nurseries. However, there has been limited research that actually compares a region’s native plant species with similar ornamental plants in regards to; pollutant filtration, plant growth, and establishment within a bioretention system. For this comparison study a total of 8 plants were selected from four different genera. A field experiment evaluated the ability of the selected plant species to establish and perform under field conditions. Plants were evaluated bi-weekly from August to November 2012 and April to October 2013 by digital photographs to determine percentage plant cover using a Leaf Area Index method in Photoshop CS 6.0 image software (Adobe Inc.).
The greenhouse experiment is conducted to evaluate the plants capability of capturing common pollutants from stormwater. Water leached from the columns was collected and analyzed for potential removal of; ortho-phosphate, organic nitrogen, nitrogen oxides, ammonia, lead, zinc, and copper from water. Additionally, plant tissue and soil samples are taken at the beginning and end of the experiment to determine the uptake of contaminants by plants and that retained by the soil.

Keywords: bioretention, stormwater runoff, native plants, pollutants

* James Coletta, 581 Lexington Ave., East Lansing, MI coletta1@msu.edu

Le, Nga

Soil Bacterial Resistance to Ciprofloxacin in Mangrove Growing Soils, Can Gio, Vietnam

Nga P. Le*, University of Science, Binh T. Pham, University of Science, Thuy T.T.Hoang, University of Natural Resources and Environment, Loan C.T. Tu, University of Natural Resources and Environment, Quoc P.Dao, Institute for Environment and Resources

Along the coastal of Vietnam, in the sea wetland areas like Can Gio mangrove forest, people are raising commercial shrimps. To prevent the bacterial diseases the farmers have often used several kinds of antibiotics. These antibiotics are proposed to cause negative effects to the aquatic environment such as antibiotic resistance in the soil/sediment microbial communities in which the resistant genes can be transferred horizontally. Our study was to investigate Ciprofloxacin (one of common antibiotics being used) resistance of the bacterial communities in Can Gio wet soils with and without planting the mangrove trees (*Rhizophora apiculata Blume Fl. Javae*). The experimental soils were chronically exposed to Ciprofloxacin along 28 experimental days. The data show that there was a clear shift of the bacterial communities toward the resistance to Ciprofloxacin in the soils without or with the mangrove trees. The resistances could get up to 100 mg/ml antibiotic in the in-vitro tests. No significant difference in the number of the resistant bacteria as function of the plants, but the diversity of the whole population (16S rRNA genes). Under antibiotic stress, the bacterial diversity was reduced remarkably in the soils alone, but unchanged significantly in planting soils. Thus the mangrove trees might help to protect the diversity of the soil bacteria against Ciprofloxacin.

Keywords: soil, mangrove, bacteria, ciprofloxacin, antibiotic resistance

* Nga P. Le, 227 Nguyen Van Cu Street, District 5, Ho Chi Minh City, Vietnam
lephinga1@hotmail.com or lpnga@hcmus.edu.vn

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Mehmood, Ansar

Phytosynthesis and Antibacterial Activity of Silver Nanoparticles using Bark Extract of *Melia azedarach* L.

Ansar Mehmood*, UAJ&K, Ghulam Murtaza, UAJ&K, Tariq Mehmood Bhatti, PIEAS

Nanotechnology is reliant on the synthesis of diversified nanoparticles by using various methods. The use of biological system for the synthesis of nanoparticles is the simplest and reliable. The synthesis of silver nanoparticles was achieved by treating the bark extract of *Melia azedarach* L. with silver nitrate solution at room temperature. The synthesized silver nanoparticles were spherical, crystalline, size ranges from 30-45 nm and showed an absorption peak at 449 nm. The characterization was made by using uv-visible spectroscopy, scanning electron microscopy, transmission electron microscopy, energy dispersive X-ray analysis, X-ray diffraction analysis and fourier transform infra-red spectroscopy. Fourier Transform Infrared Spectroscopy of nanoparticles indicated the presence of biomolecules, which may be act as capping agents around the nanoparticles. The silver nanoparticles synthesized from bark extract of *M. azedarach* showed inhibitory activity towards *E. coli* and *Klebsiella pneumonia*. It was concluded that the phytosynthesis of silver nanoparticles is reliable and eco-friendly process as compared to physical and chemical methods which are hazardous and laborious. Moreover silver nanoparticles may have important edge over conventional antibiotics.

Keywords: silver nanoparticles, *Melia azedarach*, SEM, non-toxic, TEM

* Ansar Mehmood, University of Azad Jammu and Kashmir Muzaffarabad, Pakistan
ansar.mehmood321@gmail.com

Hill, Jen

Opuntia humifusa for Potentially Improved Hydrological Performance of Green Roof Systems in Southern Ontario

Jenny Hill*, University of Toronto

Various strategies are being testing to improve the resiliency of green roofs under new and changing climatic conditions, one of which is to alter the vegetation profile used. Most studies to date have focused on the survivability of selected species, an imperative but not exclusive factor. This project will employ an alternative lens to focus on the performance of the plants as part of the urban hydraulic infrastructure. *O. humifusa*, is native to Southern Ontario and currently under the protection of the 2007 Endangered Species Act. Whilst the natural habitat of *O. humifusa* may be threatened and dwindling, it is well suited to the proposed application, as an addition to green roofs, for a number of reasons including rapid water uptake, drought tolerance, and wide temperature tolerance, down to -24 °C. Experimental container plantings are situated on the rooftop at the University of Toronto throughout the growing season of 2013. Short term hydrological performance is assessed by lysimetry and other field measurements, whilst the seasonal performance is assessed using a simple bucket model to describe water balance and compare with sedum and grass type systems.

Keywords: green roof, cactus, hydrology

* Jenny Hill, 35 St George Street, Toronto, ON Canada j.hill@mail.utoronto.ca

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Truyens, Sascha

An *Arabidopsis* model for seed endophyte-assisted plant growth upon Cd exposure

Sascha Truyens*, Hasselt University CMK, Sofie Thijs, Hasselt University CMK, Nele Weyens, Hasselt University CMK, Jaco Vangronsveld, Hasselt University CMK

Endophytic bacteria live inside plant tissues without harming their host. They can have plant growth promoting abilities, such as the production of plant hormones, or possess contaminant sequestration/degradation mechanisms. Enrichment of these endophytes in the plant after inoculation can enhance growth and reduce phytotoxicity in plants growing on contaminated soils, which is important in improving the efficiency of phytoremediation. Especially seed endophytes can play a significant role in this process: they are transferred from generation to generation and can possess characteristics which are important for germination and seedling development.

We used the model plant *Arabidopsis thaliana* to demonstrate that transgenerational exposure to Cd induces shifts in the seed endophytic population. Some bacterial genera were plant-dependent, as they occurred in both Cd-exposed and non-exposed control seeds, while others seemed to be contaminant-dependent. Also phenotypic differences occurred in the endophytes: metal tolerance and 1-aminocyclopropane-1-carboxylate deaminase activity were more often found in bacteria isolated from seeds of Cd-exposed plants compared to non-exposed controls. Preliminary screenings indicated that several of the isolated bacteria were able to promote growth of *Arabidopsis* after inoculation in the presence of Cd. However, these results were not consistent during subsequent experiments. The inoculation success seems to be correlated with the growth stage of the bacterial strain at the time of inoculation. Growth curves of several endophytic strains were established and motility in different growth stages was compared. Colonizing capacity and plant growth promoting abilities of the strains in their different growth stages were compared after inoculation of *Arabidopsis*.

Keywords: endophytes, cadmium, phytoremediation, plant colonization

* Sascha Truyens, Agoralaan building D, 3590 Diepenbeek, Belgium,
sascha.truyens@uhasselt.be

Kennen, Kate

Integrating Phytotechnology and Landscape Design

Kate Kennen*, Offshoots, Inc & Harvard University Graduate School of Design, Niall Kirkwood, Harvard University Graduate School of Design

'Phyto: A Resource for Landscape Design' is a book manuscript currently scheduled for publication by publishers Routledge of London in fall 2014; it will translate the science of phytotechnology into an easy-to-read, daily desk reference for the professions of landscape architecture, planning, and design. This presentation will highlight the most current case studies and design typologies developed for the book including the potential environmental, spatial, cultural and aesthetic qualities of productive vegetation, and summarize recommendations for productive site design.

Landscape architects are increasingly focused on optimizing natural systems and including plantings that provide ecosystem services in designed environments. Phytotechnologies have the capacity to play a significant role in transforming contaminated urban land, providing a more sustainable choice for land planning. They can also be used to help buffer the non-contaminated site, where the risk of pollution could be possible. However, the science of phytotechnologies is often misunderstood by designers, therefore this work creates visual aids and diagrams to clarify phytotechnology concepts. Drawings and charts illustrate various types of programmatic sites (i.e. gas stations, road corridors, railway beds etc) and aesthetic and functional design solutions by land use are considered. The creation of productive landscapes is the ultimate objective; plantings that provide not only aesthetic functions, but enhance environmental and human health conditions as well. The work bridges the critical science and engineering associated with phytotechnology and its effective design use in the field.

Keywords: landscape architecture, design, phytotechnology, phytoremediation

* Kate Kennen, Offshoots, Inc. 547 Rutherford Ave, Boston, MA 02129
www.offshootsinc.com, kate@offshootsinc.com and kkennen@gsd.harvard.edu

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Famulari, Stevie

A User Friendly Phytoremediation Database:
Creating the Database, the Intended Users of the Database, Teaching with the Database

Stevie Famulari*, Environmental Artist, NDSU, Kyla Witz, NDSU Alumni

Designers, students, teachers, gardeners, farmers, landscape architects, architects, engineers, homeowners and others have uses for the practice of phytoremediation. This research looks at the creation of a phytoremediation database (http://www.ndsu.edu/pubweb/famulari_research/) which is designed for ease of use for a non-scientific user, as well as for students in an educational setting. During 2012 Environmental Artist & Professor of Landscape Architecture Stevie Famulari, with assistance from Kyla Witz, a landscape architecture student, created an online searchable database designed for high public accessibility. The database is a record of research of plant species which aid in the uptake of contaminants, including metals, organic materials, biodiesels & oils, and radionuclides. There are multiple interconnected indexes categorized into common and scientific name of the plant, contaminant name and contaminant type. Photographs of the plants, hardiness zones, specific plant qualities, full citations to the original research and other relevant information aid users in a fuller understanding of uses of designing with phytoremediation during their search for potential plants which may be used to address their site's need. The terminology link is a response to be user friendly to a larger scope of people, from the inexperienced practitioner to educators of the field. The objective of the terminology section is to remove uncertainty for more inexperienced users, and to clarify terms for the a more user-friendly experience. Implications of the work including education and ease of browsing for the users, as well as use of the database in teaching are discussed.

Keywords: database, teaching, user, user-friendly

* Stevie Famulari, 620 10th Avenue North, Fargo, ND 58102 stevie@steviefamulari.net

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Lin, Chung-Ho

The Healing Power of Mother Nature- Bioremediation and Phytochemical Research at University of Missouri Center for Agroforestry (UMCA)

Chung-Ho Lin*, University of Missouri-Columbia

Mother Nature offers a wide range of functional organisms, chemicals, and biomolecules that have been utilized to clean up the environments, fight against diseases, and provide sustainable sources of energy throughout human history. The Bioremediation and Phytochemical Program at UMCA has developed a multidisciplinary research program with participating scientists, international collaborators and industry partners to exploit these powerful tools offered by Mother Nature to *1)* remediate the contaminated soils and waters, *2)* improve drug designs against human pathogens, and *3)* develop cost-effective and sustainable processes for biofuel production. Interdisciplinary expertise ranges from natural product chemistry, bacterial molecular genetics, medical microbiology, analytical chemistry and structural biochemistry to bioinformatics. The developed knowledge inspired by nature contributes significantly to developing ecologically friendly and cost-effective strategies to protect environments, improve public health and generate energy. Findings from these research projects also provide the economic opportunity to turn the abundant, low value, renewable resources into a lucrative industry in Missouri and the partnering countries.

* Chung-Ho Lin, 203 ABNR Natural Resources Building, University of Missouri, Columbia MO65211, Linchu@missouri.edu

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Ogundola, Adijat Funke

Biodegradation of (PAH) Compounds in the Rhizosphere of *Bamboosa vulgaris* in a Crude Oil Polluted Soil in Bairra, Niger Delta, Nigeria

Adijat Funke Ogundola*, Ladoke Akintola University of Technology, Rasheed Olufemi Awodoyin, Universty of Ibadan, Olugbenga Adewumi Ojo, andOlusola Alofe, Ladoke Akintola University of Technology

During the monitoring of crude oil spillage in December, 2012 at 40 Days After Pollution (DAP) in Bairra community, Niger Delta, Nigeria, it was observed that *Bamboosa vulgaris* plant naturally dominated the crude oil polluted site, indicating that this plant is tolerant to the adverse effects of crude oil spillage. This observation leads tothe investigation of the rhizosphere effect of this plant on the degradation and removal of Petroleum Aromatic Hydrocarbons (PAH) compounds from the crude oil polluted soil. Accordingly, samples were collected from the rhizosphere and non-rhizosphere soil and analysed. Results show that the rhizosphere soil of *Bamboosa vulgaris* was rich in total heterotrophic bacteria and oil-degraders. In the rhizosphere soil, oil-degraders were (46.5%) while the non-rhizosphere soil (5.8%). Residual (TPH) in the non-rizosphere soil was 3.53% (w/w), while in the rhizosphere soil the percentage was 1.0% (w/w).Thisindicate a reduction of 65% of the TPHs. The saturates fraction in the rhizosphere as compared to the non-rhizosphere soil was reduced by 90.1%, while the aromatics were reduced by 65.7%. It is of interest to find that the non-degradable asphaltenes and resins were reduced in the rhizosphere by 1.8% and 3.3% respectively. As in total the amount ofPAHs (mgkg^{-1} soil) were 1253.80 and 596.72 in the non-rhizosphere and rhizosphere soil respectively, i.e. with a loss of 47.6%. As in total the four-ringed PAHs as compared to other PAH groups were highly reduced (66.7%) in the rhizosphere, this was followed by the three-ringed PAH group (58.3%).

Keywords: biodegradation, rhizosphere, *Bamboosa* vulgaris, Poly Aromatic Hydrocarbons(PAHs), Total Petroleum Hydrocarbons (TPH)

* Adijat Funke Ogundola, Department of Pure and Applied Biology,Faculty of Pure and Applied Sciences,Ladoke Akintola University of Technology, Ogbomoso, Oyo State.
adfogundola@yahoo.com

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Ojo, Olugbenga Adewumi and Toosin Fadipe

Biodegradative Potentials of Rhizosphere Microorganisms Associated with Tropical Grasses and Legumes on Crude Oil Polluted Soils in Biarra Niger Delta.

Olugbenga Adewumi Ojo*, and, Toosin Fadipe, Ladoke Akintola University of Technology, Adijat Funke Ogundola, Ladoke Akintola University of Technology, Rasheed Olufemi Awodoyin, Universty of Ibadan

Phytoremediation is a promising technology for the cleanup of crude oil contaminated soil. In the present work the rhizosphere of *Calopogonium mucunoides*, *Cyperus rotundus* and *Sorghum arudinaceum* plants which were common in Biarra oil producing community in Niger Delta were examined for their abilities to stimulate the microbial degradation in soil polluted with crude oil. Association of these plant roots with total bacteria, fungi and oil-degrading microbeswas confirmed from the (R+/S+) ratios which ranged from 70.7-273.1 (for total bacteria), 35-149.4 (for fungi) and 118.9-330.7 (for oil-degraders). Percentages in the rhizosphere soil of these plants are (70.4%, 22.3% and 20.1% respectively). The results of the biodegradation of oil and its fractions showed that great reduction (43%) of (TPHs) was observed in the rhizosphere soil of *Calopogonium mucunoides,* 18.2% and 15.5% in those of *Cyperus rotundus* and *Sorghum arudinaceum* respectively. It was observed also that in the polluted soil, the TPHs were reduced by 9.1-11.8% as a result of biostimulation process only. The results also showed that *Calopogonium mucunoides* rhizosphere was able to reduce more of the saturated (49.8%) and more of the aromatics (29.2%) fractions, compared to (38.6% and 9.5%) for *Cyperus rotundus* and (35.9% and 5.1%) for *Sorghum arudinaceum* rhizospheres. It is of interest to find that 6.5% of the hardly degradable fraction resins was degraded in rhizosphere soil of *Calopogonium mucunoides*..Results clearly demonstrated that*Calopogonium mucunoides*(legume) provided successful phytoremediation process of a contaminated soil as compared to the other two grass plants.

Keywords: oil-dergrading, microorganisms, crude oil, rhizosphere, Total Petroleum Hydrocarbons (TPHs)

* Olugbenga Adewumi Ojo, Department of Crop and Environmental Protection,Faculty of Agricultural Sciences,Ladoke Akintola University of Technology, Ogbomoso, Oyo State
adfogundola@yahoo.com

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Nurzhanova, Asil

Use of Phytotechnologies for Remediation Soil of Kazakhstan Contaminated by Pesticides

Asil Nurzhanova*, IPPB Kazakhstan,Sergey Kalugin, KazNU Kazakhstan, Rosa Baizhumanova, KazNU Kazakhstan

Widespread use of pesticides in agricultural practices mean that all countries, including Kazakhstan, one way or another are faced with stockpiles of obsolete pesticides. Source of toxic chemicals into the ecosystem are the former warehouses of pesticides and use of phytoremediation technologies seem here appropriate.

In field test, two test plots were set up at sites around of the former warehouses to study the effect of added fertilizers/surfactants on phytoextraction in monoculture/mixed culture by *Cucurbita pepo L. pumpkin,Xanthium sturmarium*, *Ambrosia artemisifolia*, *Artemisia annua,Amaranthus retroflexus* and *Helianthus annuus.* Two control treatments included the contaminated soil without fertilizer/surfactants and without plants and the contaminated soil with fertilizer/surfactants and without plants.

Shows the initial mass of pesticide in the soil was reduced by more than one-half in a single growing season. Plants accumulated significant concentrations of pesticides into plant tissue compared to the initial concentrations in soil; however, the mass pesticides taken up into plant tissue represents a very small fraction of the total pesticides mass in the soil. Therefore, the reduction of pesticide concentrations in soil was not due to plant uptake of pesticides. Other processes are mostly responsible for changes in pesticide concentrations in the soil. Additions of fertilizer/surfactants appeared to increase plant biomass production and increase the amount of pesticide accumulated in plant tissue, translocation factor and biological absorption coefficient. The decline observed in soil pesticide concentrations suggests practically useful soil remediation processes may be functioning; however, mechanisms other than phytoextraction are apparently responsible for this change.

Keywords: soil, wild plant, phytoremediation, dichlorodiphenyltrichloroethane, hexachlorocyclohexane

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De Moor, Sofie

Feasibility of Grass Co-Digestion in a Typical Flemish Agricultural Digester, Influence on Process Parameters and Residue Composition

Sofie De Moor*, Ghent University, Evi Michels, Ghent University, Isabella Wierinck, Organic Waste Systems Belgium, Erik Meers, Ghent University, Biogas-E Belgium

The European Union states that by 2020, 20% of the European energy consumption should come from renewable energy. This study investigated the potential of co-digestion of grass clippings (waste) in a typical Flemish agro-digester characterized by an input of 30% manure, 30% maize silage and 40% side streams. No significant adverse effects in the microbiological functioning of the reactors were detected when 10 to 20% out of the 30% maize input was replaced by grass. However at the highest dosage of grass input, dry matter content and the viscosity of the reactor content increases substantially. These elevated parameters could subsequently be reduced again by enzyme addition in the form of MethaPlus L100, although they remained higher than those of the reference reactor receiving maize. It can be concluded that co-digestion of 20% grass in a typical agricultural digester would not pose any problem if dry matter content and viscosity are improved by the use of an enzyme mixture. This is good news for a region like Flanders, where arable land for (energy) crop production is scarce and where grass wastes remain in many cases unused.

Keywords: anaerobic digestion, grass clippings, semi-continuous system, mesophilic co-digestion, agro-digester

* Sofie De Moor, Coupure Links 653, B-9000 Ghent, Belgium sofie.demoor@ugent.be

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De Moor, Sofie

Biomass Yield and Phytoextraction Potential of Short Rotation Coppice Poplar and Willow on Cd/Zn Contaminated Soils – Extended Field Experiment in the 2nd Growth Cycle

Sofie De Moor*, Ghent University, Matthias De Fraeye, Ghent University Evi Michels, Ghent University, Filip Tack, Ghent University, Erik Meers, Ghent University

The use of biomass crops to phytoremediate soils whilst simultaneously producing a valuable non-food crop, is an approach which is enjoying increasing attention. A Cd and Zn contaminated test site in the Campine region was planted with five poplar clones and eight willow clones six years prior to this study. The estimated total biomass production in the 2nd year of the 2nd growth cycle varied from 2.22 to 8.15 ton DM ha^{-1}, with the willow clone Jorr giving the highest yield. Loden accumulates the highest amount of Cd (418 ± 87 g ha^{-1}) and Zn (10.2 ± 0.7 kg ha^{-1}) in its wood. With this clone it would take 88 to 133 years to remediate the soil. Due to the long remediation time however, it is more realistic to aim for maximum biomass production using highly productive clones (Jorr). The concept of focusing on biomass productivity first and metal removal second is referred to as 'phytoattenuation'. Productivity increases could be observed upon application of 5% compost before planting. An important note is that Cd is accumulated 2 to 3 times and Zn 4 to 9 times more in the leaves than in the wood. As the leaves are normally not harvested, a vast extraction potential is unutilized and this also entails a risk of spreading of the pollution through litterfall. Two solutions (adaption planting scheme or shortening rotation time) for this problem were proposed and should be investigated in future research.

Keywords: short rotation coppice (SRC), contaminated soil, cadmium (Cd), zinc (Zn), phytoattenuation, phytoremediation

* Sofie De Moor, Coupure Links 653, B-9000 Ghent, Belgium. sofie.demoor@ugent.be

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Rutter, Allison

Assisted Revegetation Following Contaminated Site Remediation in the Arctic: Cape Dyer (DYE-M) Baffin Island and Resolution Island (BAF-5), Nunavut

Allison Rutter*, QUEENS, Barbara Zeeb, RMC, Sarah Ficko, RMC, Brandon Smith, RMC

Construction, operation, and maintenance of a large DEW Line Station at Cape Dyer (DYE-M) Baffin Island, Nunavut from 1956-1989 resulted in the contamination of soils and ground water at numerous locations of the site. In 2008, extensive remediation work was conducted to remove material from several buried landfills resulted in approximately 19700 m^2 of land devoid of vegetation. These areas are less stable and more vulnerable to wind and water erosion, unable to provide food or habitat for animals, and visually unappealing. Re-establishment of plant cover through natural succession events is a long and slow process in the Arctic. In 2009, a pilot-scale project was initiated at the site to investigate the feasibility of using *assisted revegetation* to accelerate revegetation. First, ca. 500 *Salix arctica* cuttings were collected from a nearby donor population following a frost, and transplanted in plots of ~20 cuttings, to create small 'islands' within each unvegetated area to accelerate growth of these woody perennial species. Second, 50 pounds of *Lolium multiflorum* was used as a 'nurse grass' to establish an immediate plant community, and provide windbreaks to help trap native seeds blowing across the unvegetated areas. Third, ripe seeds and berries from native species were collected from areas surrounding the disturbed sites and spread across all unvegetated areas. In July 2010, it was determined that 95% of the *S. arctica* cuttings planted in September 2009 had survived the winter and produced new shoot growth. Furthermore, significant root development was found on excavated specimens. The work was continued in 2011 and at that time a second site (BAF-5) was assessed for assisted revegetation. Monitoring work continued in 2012 with a reassessment of the plant diversity on all planted areas.

Keywords: assisted re-vegetation, ecorestoration, Salix, Arctic, remediation

* Allison Rutter, Analytical Services Unit., School of Environmental Studies, Queen's University, Kingston, ON K7L 3N6 ruttera@queensu.ca

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Doucette, Bill

Use of Plants as Passive Samplers for Volatile Organic Compounds (VOCs) in Indoor Environments.

Bill Doucette*, Utah Water Research Laboratory, Todd Wetzel, Utah Water Research Laboratory

Volatile organic compounds (VOCs), including many with documented short- and long-term adverse health effects, can enter indoor environments through internal (i.e. paints, paint strippers, fuels, cleaning supplies, pesticides, building materials, adhesives) and external sources (i.e. vapor intrusion from contaminated groundwater). Indoor air concentrations of VOCs vary widely, but concentrations of most VOCs are consistently higher indoors than outdoors. Typical approaches used to sample indoor air include evacuated canisters and sorbent tubes. The use of ornamental plants has been suggested as a simple, unobtrusive, aesthetically pleasing, and cost effective method for sampling and purifying indoor air. The waxy surface of the leaves has the potential to provide a good surface for the passive capture of VOCs. However, the efficiency and kinetics of capture have not been well characterized. To investigate the potential use of plants as indoor air VOC samplers, three types of studies were performed. The first consisted of monitoring air and plant concentrations over time after a controlled release of several VOCs into a residential building containing several plant species. The second study used a flow-through glass and stainless plant growth chamber to evaluate the relationship between air and plant leaf VOC concentrations. The third study used a headspace approach to measure equilibrium leaf-air partition coefficients. Good correlations between the leaf and air concentrations observed in the three different studies suggest that plant leaves can be used to monitor indoor air concentrations of VOCs.

Keywords: indoor air, VOCs, plants, sampling, leaf-air partition coefficients

* Bill Doucette, Utah Water Research Laboratory, Utah State University, 8200 Old Main Hill, Logan, UT 84322-8200 william.doucette@usu.edu

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Goswami, Chandrima

Lead Removal Efficiency and its Accumulation by *Lemna minor*

Chandrima Goswami*, Jadavpur University, Arunabha Majumder,Jadavpur University, Amal Kanti Misra, Jadavpur University, Kaushik Bandyopadhyay, Jadavpur University

Heavy metal pollution of water is a major threat to the environment. Hence phytoremediation, an emerging green technology has been accepted as an eco-friendly and cost-effective step for cleanliness of the environment. The present research work demonstrates the study of the phytoremediation potential of duckweed *Lemna minor* for the removal of lead from aqueous solution. Initial lead concentrations were kept between 0.5mg/L and 3.0mg/L. The results showed that the percentage of lead removal increased with the increase of contact period, whereas it decreased with the increase in the initial concentration of lead in the aqueous solution. In case of all experimental studies with varying initial lead concentrations, maximum removal was obtained on the 22nd day of the experimental period. More than 80 percent of lead removal was achieved by *Lemna minor* in each case. The results of the Relative Growth Factor (RGF) revealed that increase in initial concentration of lead affected the relative growth of *Lemna minor,* as compared to control. The results of metal accumulation after the harvesting period of 22days highlighted that the lead accumulation increased with the increase in initial concentration of the metal in water. *Lemna minor* was found to hyperaccumulate lead at initial concentrations of 2.0 and 3.0mg/L with BCF values of 1216.12 and 1319.65 respectively. Thus Lemna minor has been found to be effective in the phytoremediation of lead from water.

Keywords: lead, phytoremediation, *Lemna minor,* bio concentration factor

* Chandrima Goswami, Department of Construction Engineering, Jadavpur University, Kolkata-700098juhi262@gmail.com

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Hong, You-wei

Quantification of PAH dioxygenase genes from Rhizoplane and Endophytic Bacteria in Wetland Plant Roots

Youwei Hong*, Shen Yu, Yongshan Chen, Jianqiang Su, Jing Ding, Jinbo Gao,Jun Ma
Key Laboratory of Urban Environment and Health, Institute of Urban Environment, Chinese Academy of Sciences

Changes of PAH-ring hydroxylating dioxygenases (PAH-RHD_{α}) from gram positive (GP) and gram negative (GN) bacteria in wetland plant roots were investigated. PAH-RHD_{α}-GP primer set was designed against the genes (narAa, phdA/pdoA2, nidA/pdoA1, nidA3/fadA1), while PAH-RHD_{α}-GN was composed of nahAc, nahA3, nagAc, ndoB, ndoC2, pahAc, pahA3, phnAc, phnA1, bphAc, bphA1, dntAc and arhA1. After exposed to phenanthrene (PHE, 10 and 100 mg/L) and pyrene (PYR, 10 and 100 mg/L) contaminated sediments for 10 weeks, the copy number of PAH-RHD_{α} from rhizoplane and endophytic bacteria in roots of *Spartina alterniflora* were quantified using real-time PCR assays. Rhizoplane bacterial PAH-RHD_{α}-GP abundances ranged from 8.38×10^{6} to 1.70×10^{7} copies per gram root, PAH-RHD_{α}-GN from 1.83×10^{6} to 4.77×10^{7} copies. As for endophytic bacteria, PAH-RHD_{α}-GP abundances ranged from 1.50×10^{6} to 2.47×10^{6} copies per gram root, PAH-RHD_{α}-GN from 1.44×10^{5} to 4.96×10^{5} copies. The greatest abundance of PAH-RHD_{α}-GN in rhizoplane and endophytic bacteria were found at the 100 mg/L PHE treatment, with the increasing by more than 100- and 3-fold, up to 4.77×10^{7} and 4.96×10^{5}, respectively. However, there was no significant difference for PYR treatments ($P > 0.05$). On the other hand, the copy number of PAH-RHD_{α}-GP was enhanced by the increase of PHE or PYR concentrations. The results indicated that these genes may serve as biomarkers for PHE pollution. Therefore, this study demonstrates a positive correlation between PAH biodegradation potential and the PAH-contamination level in the wetland environment, which might play important roles in bacterial endophyte-enhanced phytoremediation in wetland ecosystem.

Keywords: endophytic bacteria, rhizophere, PAH-ring hydroxylating dioxygenase gene, Real-Time PCR, *Spartina alterniflora*;

* Youwei Hong, 1799 Jimei Boulevard, Xiamen 361021, China ywhong@iue.ac.cn

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Gupta, Rakesh

Utilizing inhabitant weeds for phyoremediation of the industrey polluted agriculture lands

Rakesh Gupta*, Lovely Professional University and M.I.S.Saggoo, Punjabi University

Release of toxic industrey effluents specially the heavy metals is taking place in irrigation and local drains whose water is frequently used to irrigate Cultivation fields in the fertile land of India .Toxic heavy metals are getting accumulated in soil,Crops and thus to human diet ,damaging the human health and Environment in addition effecting the quality Crop production. The heavy metal containing effluents from Industrial Complex, Jalandhar are discharged in the Kalasinghia drain which moves through the agricultural fields of Jalandhar –Kapurthala belts in Punjab,India and is the current investigation site.Local weeds were selected to remediate the soils as they are acclimatise for environment pollution stress and some of them are potential metal accumulator as was found during investigation. To get detail analysis of soil and weeds samples ,four polluted sites were marked for conducting the study. The control area was about 15 kilometers away where only tube well irrigation is taking place. Samples of soil and the plants were collected in triplicates from the polluted as well as the control site.Metal accumulation in the aerial parts, and roots was investigated in the plants . Samples were acid digested and heavy metal accumulation was estimated using ICAP-AES method. Pot experimentation,Hydroponics were conducted and Bioaccumulation factor(BAF),Enrichment Factor (EF),Translocation factor(TLF) were calculated for different heavy metals like Cr, Cd, Cu, Pb, Ni and Zn and better phyoremediator weeds were screened . Tolerance index (TI) AND Phytoextraction Capacity (PC) were also evaluated to screen better remediators .Many plants are reported to be good phytoremediator due to effficent metal accumulations. According to Baker et al (2000) the local growing plants can be good phyoremediator in polluted soils.The wild growing species can remediate the polluted soils where they are growing (Delio etal 2000).This study showed that theses weeds can be used as the phytoremediators to cure the problem of heavy metal industry pollution in cultivation lands of INDIA .

Keywords: Bioaccumulation factor,Transloaction factor,Phytoextraction capacity.

Rakesh Gupta, School of Biotechnology, Lovely Professional University144002, Phagwara ,Punjab,INDIA

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Adeoye, Comfort

Phytoremediation, Panacea to Mopping up Strategy of an Extreme Eoil Contamination. Case Study: Kumapayi Battery Waste Dump Contamination, Ibadan, Nigeria.

Comfort Adeoye*, University of Ibadan, Oladele Osibanjo, University of Ibadan, Gideon Adeoye, University of Ibadan

Post Impact Assessment (PIA) was carried out on battery waste dump at a local community, Kumapayi village in 070 25'N, 040 10' E, Oyo State in Nigeria. Representative soil, water, plant samples were taken both at the pollution and nearby points that are unpolluted as control. These samples were analyzed for physical, chemical composition using standard methods. The chemical parameters include macro and micro nutrients. Lead (Pb) was specifically monitored as the major pollutant from the battery industry. The result showed a high range of Pb levels (> 4,000 mg/kg in roots of grass: *Cynodon dactylon, Imperata cylindrical and Panicum maximum* and 300,000mg/kg in soils of the dumpsite. Nuggets of Pb are even collected by scavengers and at the reconnaissance stage a woman and her son were found collecting lead with hands. They have clinical symptoms of Pb Poisoning, especially the cyanosed boys visage. There is high correlation between Pb and organic matter. The effect of the waste corroded the cemented foundation of the house. Animals found eating grasses and arable crops; fruits and vegetables are at the risk of taking up Pb, which could become a global danger when crops from peri-urban garden sold in the market is consumed. Therefore, It is concluded that Pb poisoning is a potential danger in Kumapayi dumpsite and phytoremediation is recommended as key mitigating strategy to remediate the soil, monitor and protect secure the health of the population, animals and plants.

Keywords: post impact assessment, battery dumpsite, clinical symptoms, kumapayi dumpsite, phytoremediation

* Comfort Adeoye, University of Ibadan, Ibadan, Nigeria comfortadeoye@hotmail.com, kutulolaola@yahoo.com

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Adeoye, Gideon

An Aggressive Invading Weed that Poses Challenge to Organic Agriculture in Nigeria is a Potential Phytoremediator

Gideon Adeoye*, University of Ibadan Nigeria, Comfort Adeoye, University of Ibadan Nigeria, Morenike Adeoye-Isijola, Babcok University

In Nigeria an unclassified noxious and aggressive weed has invaded the farming system. Till now Taxonomists have been trying to classify the weed.Can you help us?It took over our organic ginger, tumeric, maize and cassava farms.The bulk volume of soil taken by the root in the rhizosphere is 10-100 times the biomass weight. It thrives where other weeds and cultivated crops fail. It is an indicator plant for deficiency symptoms in soil fertility evaluation of essential elements. When hand weeded, the stems re-establish themselves with ease because nodes and even internode cells develop roots easily.The prevailing weeds in the ecosystem - *Chromolina odorata* and *Tithonia diversifolia* are displaced by this noxious weed. The weed resembles *Aspilia spp* but the leaves and inflorescence are distinct. The weed is suspected to be a cross in the family *Asteracea.*Because of its economic devastation in the farming system, reducing yield of crops below economic levels it is named in Yoruba Language in Nigeria (‘Polokolekun’ or ‘Yomiloju oloko’) interpreted as ‘make farmer to shed tears or to weep for sorrow because of crop failure and economic loss. Because of the root volume and active growth, it is being suggested as a test crop for phytoremediation. This plant should be discussed, investigated and classified at this conference.

Keywords: aggressive weed, invading weed, bulk volume, polokolekun, yomilojuoloko, phytoremediation

* Gideon Adeoye, Department of Agronomy University of Ibadan, Ibadan, Nigeria
kutulolaola@yahoo.com

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Yelikbayev, Bakhytzhan

Soil Formation in Reclaimed Loess in the South-Eastern Kazakhstan

Bakhytzhan Yelikbayev*, Kazakh National Agrarian University

This article presents the issues relating to the primary soil-forming process after remediation on the exposed loess for the period from 1991 to 2012.

As the result of the studies, it was found that, under influence of soil-forming factors, the phytocoenosis reached a quasi-climax stage in 15 - 16 years.During this period (1996-2012), the following syngenetic successional changes took place in loess soils: 0-2 years thin plants (rare ruderal) → 3-5 years weed encroachment (ruderaleherbae) → 6-9 years gramineous and legimenous with weed grass (heterograminae – leguminosae et ruderaleherbae ass) preclimacterium phytocoenosis (Poa pratensis, Dactylus glomerata, Agropyron repens – Tripholium pratense, Melilotus alba et Euphorbia seguierana, Artemisia absinthum, Cihorium intybus et all) →10-13(14) years gramineous and legimenous (heterograminae - leguminosae) preclimacteric phytocoenosis (Poa pratensis, Dactylus glomerata, Agropyron repens - Tripholium pratense, Melilotus alba) → 15-16 years and furthergramineous andmixed herbs (heterograminae - heteroherbae ass) quasi-climacteric phytocoenosis (Poa pratensis, Dactylus glomerata, Agropyron repens - Tripholium pratense, Artemisia absinthum, Taraxacum officinale, Medicago sativa, Silaus besseri, Vicia crassa, Arctium leiospermum et all).

In the process of syngenetic soil formation in loess deposits, the following changes were observed in morphological characteristics of the soil. For 21 years, color of loess has changed from straw-colored to dark straw-colored (according to Mansell scale from 5YR 8/2 to 5YR 6/1 or more). Although the microstructure remains of rocky type for quite a long time, and this type is the main one, when application of vermicompost in the standard amount of 27 t/ha, in loess, laid down in 1971, the “soil” characteristics of microstructure are expressed somewhat stronger.

In the process of syngenetic soil formation in loess deposits, the following processes were revealed: secondary argillization, humus accumulation, illimerization (lessivage) and leaching.

Keywords: soil formation, soil process, phytocenosis succession, loess

* Bakhytzhan Yelikbayev, Abai str.8, 050010 Almaty, Kazakhstan, Almaty, Kazakhstan
bakhytjan@gmail.com

101A

Ozdemir, Gazel Oykum

Pb and Cd Accumulation in Locally Grown Plants in Sakarya, Turkey

Gazel Oykum Ozdemir*, Sakarya University, Pinar Iscioglu Haykir, Sakarya University, Nilsu Keskin, Sakarya University, Mehmet Isleyen, Sakarya University

Pot experiments were conducted to investigate the accumulation of Pb and Cd in 5 different plants locally grown in Sakarya, Turkey. Thirty –five pots were packed with an average of 6 kg of soil containing at 250 mg Pb/Kg soil and 75 mg Cd/Kg soil (dry weight basis). The pots were divided into 6 main categories based on the following scheme: lettuce, radish, bean, corn, squash, and their 3 vegetated controls.
Heavy metal concentrations in plant compartments were measured and compared to each other. The highest root Pb concentration measured in bean was 140 mg/Kg, whereas the highest Cd value was measured as 245 mg/Kg in the roots of radish plant. Data normalized to planted controls showed that the highest leaf Pb and Cd values were calculated for lettuce plants as 7 and 43, respectively. Normalized root Cd value for radish was 345; the value was 2-11 times higher than that of data calculated for other cultivars. Interestingly, data showed that Pb and Cd accumulation were high in the plant compartments consumed by many people.

Keywords*:* phytoextration, heavy metal, Pb, Cd, accumulation

* Gazel Oykum Ozdemir, Sakarya University, Department of Environmental Engineering Esentepe Campus, Sakarya, Turkey 54187 oykumdaisy@hotmail.com

Study on Phytoremediation of Cadmium by *Pistia stratiotes* and Safe Disposal of Phytoremediated Plant

Devaleena Chaudhuri*, Jadavpur University, Arunabha Majumder, Jadavpur University, Kaushik Bandyopadhyay, Jadavpur University, Amal. K. Mishra, Jadavpur University

The aim of this study was to determine cadmium phytoremediation efficiency of a free floating aquatic macrophyte *Pistia stratiotes* from aqueous solution and finally to fabricate a safe disposal technique of phytoremediated plant. The macrophyte was exposed to six different cadmium concentrations within the range of 0.5 to 3 mg/l at an interval of 0.5mg/l for 22 days. Everyday evaporative water loss was compensated by adding fresh pond water and water sample was collected periodically for estimation of residual metal content in the media. At the end of treatment period phytoremediated plant was harvested and accumulated metal content was measured. Inhibitory effect of metal toxicity on plant growth with respect to unexposed plant was also evaluated. Cadmium removal decreased from 83.40 to 55.93 % by increasing initial cadmium concentration from 0.5 to 3.0 mg/l after 22 days of treatment. Rate of cadmium removal changed as a function of residual cadmium concentration. Equilibrium treatment period reached after 15 days of treatment. Cadmium accumulation potential was evaluated as Bio Concentration Factor (BCF). Higher cadmium concentration inhibited cadmium accumulation potential of plant. It was evident that higher cadmium accumulated in plant root than that of shoot. BCF value of root system was more than 2000 in all cases which proved it to be a good cadmium accumulator. At the end of experiment phytoremediated plant was disposed by compacting within M-25 grade concrete matrix. TCLP result confirmed the selected technique as environmentally safe disposal method of metal rich phytoremediated plant.

Keywords: phytoremediation, cadmium, *Pistia stratiotes*, disposal, Toxicity Characteristic Leaching Procedure (TCLP)

* Devaleena Chaudhuri, Jadavpur University, Construction Engineering Dept, Block:LB, Plot No. 8, Sector III, Salt lake city, Kolkata- 700098, West Bengal, India; piu.7021@gmail.com

103A

Sarkar, Supriya

Duck Weed (*Lemna minor*) – A Remedial Tool for Coke Oven Waste Water Treatment

Supriya Sarkar*, Priyanka Saha, Angela Banerjee, P. K. Banerjee, Raw Material and Coke making research group, RD &T, Tata Steel Ltd, Jamshedpur

An eco-friendly and cost effective technique- phytoremediation was used to remediate contaminants from waste water. This study demonstrated that phytoremediation ability of Duck weed (*Lemna minor* L.) to remove chloride and sulphate from Biological Oxygen Treatment (BOT) waste water of coke oven plant. The Biological Oxidation Treatment (BOT) water quality was assessed by analyzing physicochemical characters – pH, Total Dissolved Solids (TDS) and elemental concentration. It was observed that an increase in pH value indicated an improvement of water quality. The experimental results showed that, Duck weed effectively removed 30% chloride, 16% sulphate and 14% TDS from BOT waste water, which suggested its ability in phytoremediation for removal of chloride and sulphate from BOT waste water. A maximum 30% relative growth rate of duck weed was achieved after 21 days of experiment. Thus, it was concluded that duck weed, an aquatic plan, can be considered for treatment of the effluent discharged from the coke oven plant.

Keywords: Duck weed, phytoremediation, BOT water, coke oven plant

* Supriya Sarkar, Tata Steel Ltd, Jamshedpur, India s.sarkar1@tatasteel.com

1B

Lamia, Mhadhebi

Antiproliferative Activity of Aqueous Extract from the Mediterranean Brown Seaweed of the Genus *Cystoseira*

Mhadhebi Lamia*, Unité de Recherche des Substances Actives Marines (URSAM), Laboratoire de Pharmacologie and Laboratoire de Pharmacologie des Médicament Anticancéreux, Mhadhebi Amel, Laboratoire de chimie des substances naturelles et de synthèse organique, Robert Jacques, Laboratoire de Pharmacologie des Médicament Anticancéreux, Bouraoui Abderrahman, Unité de Recherche des Substances Actives Marines (URSAM), Laboratoire de Pharmacologie

The marine ecosystem with its rich diversity and abundance of natural products can contribute to the discovery of new potential drugs. The aim of this study was to investigate the effect of three aqueous extracts from the Mediterranean brown seaweed, *Cystoseira sedoides, Cystoseira crinita* and *Cystoseira compressa,* collected from the Tunisian coast, against three human tumor cell lines A549 (lung cell carcinoma), HCT15 (colon cell carcinoma), MCF7 (breast adenocarcinoma) and normal cells MDCK (Mardin–Darby canine kidney) and rat fibroblast.
The samples were defrosted before use and were then macerated in distilled water and filtered. The filtrate was lyophilized to give the crude extract.
The potential effects of the aqueous extracts on cell viability were investigated using the MTT assay as an indicator of metabolically active cells.
Aqueous extracts were tested for their effects on inhibition of cell growth against three human tumor cell lines: A549, HCT15 and MCF7, over a concentration range of 25 - 500 µg/ ml, to determine their potency. Aqueous extract of *C.sedoides* and *C.compressa* suppressed dose dependently the proliferation of HCT15, with IC_{50} values 10 and 20 µg/ ml, respectively; Aqueous extract of *C. crinita* exhibited significant cytotoxicity on MCF7 cell line with IC_{50} value 17 µg/ ml. These aqueous extracts showed a moderate cell growth inhibition in A549 cells. These findings support the need for additional investigation to clarify the features underling the antiproliferative potential of these extracts, which make them interesting for screening of natural products.

Keywords: antiproliferative, aqueous extract, *C. sedoides*, *C. compressa,C. crinita*

* Mhadhebi Lamia: Unité de Recherche des Substances Actives Marines (URSAM), Laboratoire de Pharmacologie, Faculté de Pharmacie, Avenue Avicenne, 5000 Monastir, Tunisie
mhadhebi.lamia@yahoo.fr

2B

Afelumo, Funmi

Herbicide safener treated maize overproducing anthocyanin show alleviated symptoms of nickel toxicity

Funmi Afelumo*, State University of New York, College of Environmental Science and Forestry (SUNY – ESF); Shaler Garrett, SUNY – ESF Lee Newman SUNY – ESF

Herbicide safeners are a group of chemical compounds used with cereal crops in agriculture to induce crop tolerance to otherwise phytotoxic herbicide applications. *Zea mays* (maize) seeds were treated with Herbicide safeners flurazole, dichlormid and naphthalic anhydride (referred here as NA) and exposed to low and high toxic concentrations of nickel (50 μM and 150 μM). In seedlings exposed to nickel treatment, safeners flurazole and dichlormid increased total dry biomass yield of the shoot for treated shoots compared to unsafened and NA treated seedlings, while NA treated seedlings had increased total dry biomass yield of the roots for treated seedlings compared to unsafened, dichlormid and flurazole treated seedlings. Total nickel concentrations in the maize seedling shoot and root tissue were analyzed using ICP-MS. NA treated maize at 150 μM nickel treatment translocated significantly more nickel from the root to the shoot tissue compared to the unsafened seedlings, while dichlormid and flurazole treated seedlings had nickel concentrations that did not differ significantly from the control. NA treated seedlings were also found to have an almost 3-fold increase in leaf anthocyanin content compared to dichlormid, flurazole and unsafened seedlings. Thus, anthocyanin is very likely involved in the nickel tolerance in maize seedlings

Keywords: heavy metals, anthocyanin, maize (*Zea mays*), remediation, herbicide safeners

* Funmi Afelumo, 1 Forestry Drive, Syracuse, NY 13210, 344-470-4937, oaafelum@syr.edu

3B

Islam, Shariful

Phytofiltration Mechanism of Arsenic and Cadmium using *Micranthemum umbrosum* from Water Environment

Shariful Islam*, Hokkaido University, Japan and Masaaki Kurasaki, Hokkaido University, Japan

Phytofiltration is an emerging eco-friend technology to remediate pollutants from polluted water and soil environment. Arsenic (As) and cadmium (Cd) are the most noxious and carcinogenic contaminants causing severe pollution in water environment followed by developing different kind of diseases in human being like arsenicosis, lesion in foot and hand palm, cancer, *Itai-itai* etc. *Micranthemum umbrosum* is an aquatic green plant that is capable to remove 79-89% As and 60-73% Cd from 0-1μg As mL^{-1} and 3-30μg Cd mL^{-1} solution, respectively. As and Cd detoxification or phytofiltration mechanisms in plant parts were also investigated. After *Sephadex G*-50 gel filtration of the soluble fractions of the plant grown in the water containing As and Cd, fractions of As, Cd and -SH contents were determined in shoot and leaf. Results from recent study indicated that low molecular weight substances having *thiol* groups may relate to remedy of As and high molecular weight compounds may relate to detoxify or bind Cd within plant body. The experimental results demonstrated that *M. umbrosum* has high potentiality as phytofiltrator for As and Cd. This As and Cd phytofiltration or detoxification mechanism will increase the scope of phytoremediation research for environmental contaminants.

Keywords: arsenic, cadmium, mechanism, phytofiltration, water

* Shariful Islam, Graduate School of Environmental Science, Hokkaido University, Kita 10, Nishi 5, Sapporo 060-0810, Japan sharif@ees.hokudai.ac.jp or sharifpstu@gmail.com

4B

Żmuda-Baranowska, Magdalena

Usefulness of Water Hyacinth (*Eichhornia crassipes*) Plants in Lead Phytoextraction from Contaminated Water

Magdalena J. Żmuda-Baranowska*, WULS-SGGW, Arkadiusz Przybysz, WULS – SGGW, Noor Ain Binti Yahya, WULS – SGGW, Monika Małecka-Przybysz, WULS – SGGW, Stanisław W. Gawroński, WULS – SGGW

Urbanization, especially industry development and increased transportation is, in parallel, associated with pollution of soil, air and water. Lead is one of the main pollutants of anthropogenic origin found in the waters of both Malaysia and Poland. Common method of using chemicals to treat water is unfortunately, not without negative consequences. In this study, usefulness of water hyacinth (*Eichhornia crassipes*) plants in lead phytoextraction from contaminated water was evaluated. This species, a common tropical plant in South-East Asia may also be used as an ornamental plant in Poland.

Plants were cultivated, under strictly controlled growth conditions, in plastic containers filled with nutrient solution (1/4 of Hoagland solution, pH 6.2) enriched with increasing concentrations of lead (between 0 and 1000 mg dm^{-3}). Non-destructive measurements characterizing efficiency of photosynthetic apparatus were conducted in one week intervals. Biomass accumulation and lead content were assayed at the end of the experiments.

Obtained results showed that *E. crassipes* were able to grow and accumulate extremely large quantities of lead, even up to 115.65 and 417.20 g*kg^{-1} DW, for leaves and roots respectively. Lower lead concentrations did not show any toxic effects on examined plants. Lead however in higher concentrations (above 250 mg dm^{-3}) had negative impacts on plant growth and biomass production. Total chlorophyll content, gas exchange (i.e. intensity of photosynthesis, stomatal conductance and transpiration rate) and values of the chlorophyll *a* fluorescence parameters were also lowered. These results support the conclusion that *E. crassipes* can be used in phytoextraction of lead from polluted water.

Keywords: water, lead, phytoextraction, photosynthetic apparatus, biomass accumulation

* Magdalena J. Żmuda-Baranowska, Laboratory of Basic Research in Horticulture, Faculty of Horticulture, Biotechnology and Landscape Architecture, Warsaw University of Life Sciences – SGGW, Nowoursynowska 159, 02-776 Warsaw, Poland,
magdalena_zmuda_baranowska@sggw.pl

5B

Warner, Camille

**Remediation of Trichloroethylene in a Wetland Microcosm:
The Role of Plants and Microbes**

Camille Warner*, SUNY College of Environmental Science and Forestry, Amanda Ludlow, Roux Associates, David Tsao, BP Corporation North America, Inc., Lee A. Newman, SUNY Environmental Sciences and Forestry

Trichloroethylene (TCE) is an industrial solvent that has found its way into groundwater and drinking water as a result of accidental spills and improper disposal. Exposure can have detrimental effects on the liver, kidneys, central nervous system and reproductive system, and is now classified as a human carcinogen. Because pump and treat methods are invasive and expensive, phytoremediation is increasingly being used for remediation. However, while considerable work has been done with trees and larger plants, the use of wetland plants has been little studied. For this project, a wetland microcosm will be designed with plants (*Alisma plantago-aquatica, Carex crinita, Hibiscus moscheutos, Iris versicolor, Sagittaria latifolia, Saururus cernuus, Scripus atrovirens,* and *Acorus americanus)* to investigate the efficiency of uptake and degradation of TCE. Before the addition of the plants, the substrate will be tested to the role of the abiotic and microbial components interact with the TCE by looking at TCE removal rates and formation of metabolites. In addition to determining the fate of TCE the bacterial community will be sampled before and after plant introduction to note any changes in community structure. It is expected that the organisms in the microcosm will be able to degrade a significant amount of the TCE and this research will provide valuable information regarding the removal of TCE in wetland systems.

Keywords: wetland, remediation, trichloroethylene

* Camille Warner, 416 Illick Hall, SUNY Environmental Science and Forestry, Syracuse, NY
ciwarner@syr.edu

6B

White, Jason

Role of aquaporins in the uptake of persistent organic pollutants (POPs) by *Cucurbita pepo*

William A. Berger, Connecticut Agricultural Experiment Station (CAES); · Jason C. White* (CAES)

Zucchini (*Cucurbita pepo* L. ssp. *pepo)* is capable of removing percent level amounts of chlordane and other persistent organic pollutants from soil. The mechanisms mediating this unique phytoextraction potential remain elusive. Recent efforts have focused on membrane transport proteins such as aquaporins. In addition to water, aquaporins in plants and algae can mediate the transport of certain organic molecules. Importantly, the functionality of these transport proteins can be impacted by hydrogen peroxide (H_2O_2) or elements such as Ag. The aim of our study was to investigate the effect of H_2O_2 and Ag co-exposure on the uptake of chlordane and DDT metabolites by several *C. pepo* cultivars. In addition, the impact of glycerol as a competitor for aquaporin transport was also investigated.
C. pepo was grown hydroponically for up to six weeks. The growth solution was then amended with chlordane or DDE, with selected plants also receiving varying concentrations H_2O_2, Ag, or glycerol. Following 18-96 h exposure periods, xylem sap and shoot tissues were collected and the POP content was determined. In a preliminary study with zucchini, peroxide exposure at 20 mM decreased technical chlordane content in xylem sap by 63%. Separately, peroxide at 10 mM decreased shoot trans-chlordane and DDE content by 58 and 63%, respectively, in zucchini and by 67 and 46% in squash, respectively. Similarly, 500 mg/L Ag, which may bind cysteine residues in aquaporins and inhibit solute transport, decreased DDE shoot content in zucchini by 49%. One hundred mM glycerol, which can act as a competitive solute for aquaporin transport, reduced trans-chlordane and DDE shoot content in zucchini by 15 and 85%, respectively. In squash, glycerol reduced DDE uptake by 46% but actually increased trans-chlordane accumulation by 82%. The relevance of these findings to uncovering the mechanisms of persistent pesticide accumulation in plants will be discussed. Current investigations are focused on the POP uptake abilities of *Arabidopsis* aquaporin knockouts.

Keywords: Persistent Organic Pollutants, Aquaporins, Phytoextraction, Bioaccumulation

* Jason C. White, Department of Analytical Chemistry, Connecticut Agricultural Experiment Station, 123 Huntington Street, New Haven, CT 06504 USA; Jason.White@ct.gov

7B

Hosseini, Mahshad

Effective induction of essential oil, main volatile compounds and antioxidant defense in *Rosmarinus officinalis L.* by influence of acetyl-Coenzyme A.

Mahshad Hosseini*, Islamic Azad University; Masoud Mashhadi, Kharazmi University; Akbar Boojar, Kharazmi University; Pejman Moradi, Islamic Azad University; Diba Keyhan, Islamic Azad University

Acetyl-coA is an intermediate compound that play main role in synthesis of fatty acids, growth hormones and phenolic compounds in plant metabolism. Accordingly we tried to elevate the quality and quantity of Rosmary herb and oil that are commonly used as spice and flavoring agents with highest antioxidants by influence of acetyl-Coenzyme-A. In this study this compound was sprayed on aerial part of Rosmary at concentration range 25 to 400 micro mole (μM) for three weeks with 7 days intervals.

After 7 days of treatment, the results showed significant increase in essential oil (17%) at 100 μM and considerable elevation (16-22%) in levels of Carnosic acid, 1,8 cineol and Borneol as effective essential compounds in Rosmary with respect to control. Our treatment also increased considerably the leaves membrane stability, their dry weight and chlorophyll contents maximally at 200 μM. In addition, there were 2.4 folds increase in SOD and markedly elevation in CAT activities at 50 to 100 μM. However, GPX activity did not changed considerably. On the other hand, the levels of malon dialdehyde as lipid damage biomarker and dityrosine as protein damage biomarker decreased to 55% and 31% of control respectively. Treatment at 400 μM showed some toxicity effect on the evaluated parameters.

As conclusion, Acetyl-coA was effectively able to induce metabolic processes to elevate three main essential compounds and oil percent, and antioxidant enzyme activities within aerial parts leading to prevalence and high quality of Rosmary herb and oil.

Keywords: Acetyl-coA, Rosmary, antioxidant, essential compounds

* Mahshad Hosseini, Department of Horticulture, Science and Research Branch, Islamic Azad University, Tehran, Iran.goodgirlir2002@yahoo.com

Kalogerakis, Nicolas

Cd Phytoextraction using the HalophyteSea Fennel *(Crithmum muritimum* L.)

Eleni Manousaki, TU-Crete; Kosmoula Galanaki, TU-Crete; Nicolas Kalogerakis*, TU-Crete

Halophytes have been recently highlighted as an alternative choice for use in phytoremediation technologies since they are better adapted to cope with environmental stresses, including heavy metals compared to salt-sensitive crop plants commonly chosen for phytoextraction applications. The halophyte *Crithmum maritimum*, popularly known as marine fennel or sea fennel, (Apiaceae) is a fleshy aromatic, perennial littoral shrub, naturally thriving on rocky Mediterranean, Pacific and Atlantic coasts. Besides the obvious interest as a naturally salt-tolerant plant, this species shows considerable economical and medicinal potential. The whole plant is eaten raw since its leaves are rich in several compounds, such as vitamin C, carotenoids, flavonoids, as well as bioactive substances which could be used for aromatic, medicinal, antimicrobial, and insecticide purposes.
The main purpose of this work was to assess the phytoextraction potential of *C. maritimum* for cadmium removal from contaminated soils. Thus, an eight-week long pot experiment was performed with plantsgrown onsoil polluted with 20 ppm Cd of dry weight of soil at different soil salinities (0, 0.5 and 1% NaCl). Cd tissue accumulation and the influence of saline irrigation on Cd accumulation have been investigated while bioavailable concentrations of Cd in soil have been measured. Furthermore, the responses of plant growth, water content, chlorophyll content, antioxidant enzyme activity and plant physiognomy to Cd and saline conditions were also monitored in order to obtain a better understanding of the plant tolerance to the heavy metal.

Keywords: cadmium, halophytes, pot experiment, soil marine fennel

*presenting author, Department of Environmental Engineering, Technical University of Crete, Polytechneioupolis, 73100 Chania, Greece, nicolas.kalogerakis@enveng.tuc.gr

9B

Pitre, Frederic

Screening of different plant species for phytoextraction of trace elements from the soil of a copper refinery

Séverine Hasbroucq IRBV, Werther Guidi Nissim IRBV, Hafssa Kadri IRBV, Frederic E. Pitre* IRBV, Michel Labrecque IRBV

Currently, most phytoremediation approaches use high-maintenance, short-term agricultural techniques including the planting of selected plant species that often do not belong to the spontaneous vegetation of the site. However, there is a growing interest in seeking alternatives relying on indigenous or well-adapted species that may secure the maintenance of higher local biodiversity than usual phytoremediation practices thereby allowing a more appropriate ecological approach to the specificity of the site and larger social acceptability. In the spring of 2013 we set up a greenhouse pot trial aimed at testing the suitability of nine indigenous (or adapted) Canadian species including willows, poplar, alfalfa, tall fescue, carrot, Indian mustard, switchgrass and ryegrass. We used a polluted soil from a copper refinery with very high concentrations of As, Cd, Cu, Pb, Se and Zn. A randomized block design was used with 5 blocks and 2 replicates per block. Plant assessments included plant growth (*i.e.* plant height, canopy coverage, plant survival) and physiology (stomatal conductance and chlorophyll content). At the end of the trial aboveground and root biomass were also assessed. Preliminary results show different responses among species. After one month, willows, Indian mustard and tall fescue seem to be more tolerant than the other species. At the end of trial the pollutant content in the plants as well as the soil of each pot will be analyzed in order to show the evolution of each pollutant and highlight the best performing species. More results will be available at the end of June 2013.

Keywords: soil, sediment, phytoremediation, heavy metals

* Frederic E. Pitre, Institut de recherche en biologie végétale, Université de Montréal,Montréal, 4101 Sherbrooke East, Montreal, Québec, Canada, frederic.pitre@umontreal.ca

10B

Huang, Yi

Field study on phytoremediation of the arsenic contaminated site in northeast Japan using arsenic-hyperaccumulator *Pteris vittata*

Yi Huang*, TGU; Mei Fang Chien, TGU; Shunsuke Otomo, TGU; Keisuke Miyauchi, TGU; Chihiro Inoue, TU; Ginro Endo, TGU

In Tohoku District of Japan, there are many mining activities and geothermal utilization. Those activities have generated and the contaminated arsenic finally flowed into the sea and accumulated on its floor in the past. The 2011 off the Pacific coast of Tohoku earthquake tsunami brought the marine sediments containing arsenic to wash ashore on the northeast coastline of Japan.In this study, a field experiment was conducted to evaluate purification of arsenic contamination using arsenic-hyperaccumulator *Pteris vittata* (Chinese brake fern), at the three agricultural sites contaminated by arsenic from the tsunami sediments and mining waste. Seedlings were planted in May 2012 and harvested in November 2012 to prevent the cold season, and the soil and plant samples were collected every month. Soil arsenic concentrations between these 6 months tended to gradually decrease. Approximately up to 23 mg/m^2 of arsenic was removed from the soil by *Pteris vittata*. Both arsenic concentrations and amounts in fronds of the *Pteris vittata* were increased till to October but decreased in November. Comparison of the fronds, rhizomes, roots arsenic concentrations in the last three months (September, October, November.) resulted in the extremely increased concentration of arsenic in rhizomes from September to November and greater than in fronds, indicating that accumulated arsenic was translocated from fronds to rhizomes of *Pteris vittata* in the late autumn. These results suggested that *Pteris vittata* is capable of accumulating arsenic from the contaminated agricultural sites in Northeast Japan. However, the fern fronds should be harvested before arsenic translocation to rhizomes.

Keywords: tsunami sediments, arsenic contamination, *Pteris vittata*, arsenic translocation

* Yi Huang, BRC Tagajo Campus, Tohoku-Gakuin University/ 1-13-1 Chuo, Tagajo, Miyagi Japan 985-8537 nklocalking@eng.tohoku-gakuin.ac.jp

11B

Zhao, Zhongqiu

To What Degree the Particle Sizes of Rock Phosphate Affect the Immobilization of Heavy Metals in Pb-Zn Mine Soils?

Zhongqiu Zhao*, University of Geosciencesand Ministry of land and Resources;Guangyu Jiang,University of Geosciences; Huaiquan Wang, University of Geosciences ;and Yun Wang, University of Geosciences

Soil resources have been contaminated with heavy metals by mining, processing, and smelting activities and were of great concern throughout the world. Chemical immobilization of heavy metals is one of important soil remediation methods. Phosphate-based minerals that adsorb, chelate, or complex heavy metals in soil was greatly concerned as effective heavy metals immobilizing materials. In this paper, the effects of rock phosphates (RP) with different particle sizes on immobilizing heavy metal-contaminated soils in Pb-Zn mine by a green house experiment was conducted.. Rock phosphate was added to a Pb-Zn mine soil with four different particle sizes: D97<4.26 (the diameters of 97% of the particles were less than 4.26 μm.), <36.83, <71.12 and <101.43 μm. Zea mays were grown in the treated soils. Compared to the control, addition of RP decreased metal contents in both roots and shoots significantly and the treatment of particles less than 4.26 μm at 5% rate was most effective with exception of Zn in roots and Cd in shoots. Pb contents in shoots decreased by 19.59%-37.80% by different particle sizes at the rate of 5%. At 5UP, 5P1and 5P3, Zn contents in shoots decreased by 13.55 %, 13.47% and 13.75 % respectively. Cu in roots was decreased by 18.46%-67.98% and in shoots by 16.82%-32.61% with addition of RP. Cd in roots decreased by 31.03%-74.23% and in shoots Cd decreased by addition of RP except of UP with no significant difference between addition treatments. The results indicated that, RP can immobilize the Pb, Zn, Cu and Cd in soil significantly and the effects strengthened with the particle size smaller and the rate of addition increased.

Keywords: Particle size, rock phosphates (RP), immobilization, heavy metals, Pb-Zn mine soil

* Zhongqiu Zhao, No. 29 Xueyuan Rd, Haidian District, Beijing 100083, China
zhongqiuzhao@163.com

12B

Wosu, Edwin

Bio-morphological Evaluation of Macrophytic Trajectories and Tolerance in a Polluted Tropical Soil Habitat: Implication for Phytoremediation Potential of Niger Delta Soil.

Nsirim Lucky, Edwin-Wosu*, College of Natural and Applied Sciences, University of Port Harcourt

An ecological study was carried out to determine the potentials of three species of Fabaceae plant family, for remediation of crude oil hydrocarbon polluted terrestrial environment. *Peltophorum pterocarpum* (DC.) Heyne*, Leucaena leucocephala* (Lam.) De Wit.*,* and *Crotolaria retusa* Linnwere used to evaluate remediation potentials as either hydrocarbon tolerant macrophyte (HTM), demonstrated phytoremediation macrophytes (DPM) or suspected phytoremediation macrophyte (SPM) in cleaning up soils contaminated with petroleum hydrocarbons. Biological analyses of morphological indices were carried out via classical standard analytical procedures to assess the level of biotic recovery through remediation performance by a holistic test of remediation significance using the PROC ANOVA and Duncan's New Multiple Range Test (DNMRT) procedures. Result shows that *P. pterocarpum* recorded greater (>) performance than *C. retusa* and *L. leucocephala* in leaf area, root length and chlorophyll content with significant difference *(p=0.05)*. *Crotolaria retusa* recorded greater performance (>) than *P. pterocarpum* and *L. leucocephala* in plant height, leaf number, nodulation, and biomass with significant difference *(p=0.05)*. However, non-significant in stem diameter and net assimilation rate, while *Leucaenaleucocephala* recorded greater performance (>) than *P. pterocarpum* and *C. retusa* in relative growth rate and leaf area ratio with significant difference (*p=0.05*). The bio-ecological depression shows that *Crotolaria retusa* had a higher performance with a lower depressive effect of the stressed environment while *L. leucocephala* had the least biological performance and a high depressive effect. Based on this by implication *Crotolaria retusa* could be proved more suitable for bioremediation practice in a polluted tropical Niger Delta soil.

Keywords: *Peltophorum pterocarpum, Leucaena leucocephala, Crotolaria retusa,* crude oil, soil

* Edwin-Wosu, 5323, Rivers State, Nigeria. nsirim.edwin-wosu@uniport.edu.ng

13B

Liang, Yongchao

The foliar uptake and downward translocation of trichloroethylene and 1,2,3-trichlorobenzene in air-plant-water systems

Yuhong Su, Xinjiang University, Urumqi 830046, PR China; Yongchao Liang*, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences

Currently, most phytoremediation studies focus on phytoextraction of contaminants from soil or water and few from air into soils or water. Here we investigated the foliar uptake and downward translocation of trichloroethylene (TCE) and 1,2,3-trichlorobenzene (TCB) in wheat, corn, and tomato seedlings following plant exposure to vapor-contaminated air. The results showed that both TCE and TCB could be rapidly transported from air to plant rhizosphere solution through foliar uptake and downward transport with the TCE and TCB concentrations in rhizosphere increased with exposure time and external contaminant concentration. Among the three plant species studied, the TCE and TCB downward transport followed the order of wheat > tomato > corn. The transport efficiency of TCE by the three plants was far greater than that of TCB. Within a 24-h uptake time, the amounts of TCE transported into the rhizosphere solution by wheat, tomato, and corn seedlings were 2.39 ± 0.42, 1.50 ± 0.22 and 1.45 ± 0.08 g TCE per gram of fresh weight biomass, respectively, when the initial TCE concentration was set at 12 mg l^{-1}. In a 48-h uptake experiment with corn seedlings, the TCE concentration in the rhizosphere solutions was lower in the TCE–TCB mixture system than in the single TCE system, whereas there was no significant difference in TCB concentration between the single TCB and TCE–TCB mixture systems at 48 h. The downward transport processes of TCE were inhibited, while those of TCB were enhanced in the mixed contaminant system within a 48-h uptake time.

Keywords: Downward translocation; foliar uptake; organic contaminants; rhizosphere

* Yongchao Liang, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081 P.R. China, ycliang@caas.ac.cn

14B

Brahim, Lotmani

Sandy soil amended "with Bentonite" clay enhance growth of Mediterranean halophyte species *Atriplex halimus L.* and accumulation of zinc and chromium

Lotmani, Brahim*, Hamel Abdelkader, Bakhti Abdallah et Berkani Abdallah,
Université Abdelhamid Ibn Badis de Mostaganem

In this work, absorption of zinc (Zn) and chromium (Cr) by *Atriplex halimus* cultured on sandy soil amended with bentonite were studied. Two metals (Cu and Zn) with two concentrations (62,50 mg Kg^{-1} and 125 mg Kg^{-1}) were used.
The parameters measured were plant growth, biomass production and plant metal content in different plant organs. Results showed in first, that plant growth is very affected on sandy soil than in soil amended with bentonite. The stem growth of *Atriples halimus* is more affected than root by metals in sandy soil. Cr is more toxic than Zn. The biomass decrease proportionally with dose increase of metal applied in soil. However plant biomass yield is very high on soil amended with bentonite than in sandy soil.
Atriplex halimus Mediterranean plant is saltbushes that have a grand potentiality to absorb quantities of Zn and Cr. The yield of metals absorbed must be enhanced when use 10% of bentonite as amendment in soil.

Keywords: *Atriples halimus*, Bentonite Amendment, sandy soil, Zinc, Chromium, Heavy metal.

* Lotmani, Brahim, Laboratoire Protection des végétaux,

15B

Yang, Yuangen

Comparison of Cu hyper-accumulating plants *E. argyi* and *E. splendens* in the uptake of copper –A hydroponic incubation study

Yuangen Yang*, Zhenli He, Peter J Stoffella, University of Florida, IRREC, IFAS

Root systems play an important role in the hyper accumulation of toxic metal copper (Cu) in *Elsoltzia* species, a Cu-accumulating plant. A hydroponic incubation study was conducted to compare the accumulation of Cu by E. Argyi and E. Splenden relative to root morphology. Pre-cultivated E. Argyi and E. Splenden were grown in nutrient solutions (pH~5.5) treated with Cu $(NO_3)_2$ at seven levels (including control plus six graded levels) in a green house for 2 weeks. After harvest, Cu adhering to plant roots was extracted with Na_2EDTA solution, and root morphological parameters were then measured using a root scanner. After washing and oven drying, plant tissues were digested with concentrated HNO_3 and analyzed for Cu concentration. Yields of E. Argyi and E. Splenden were significantly affected by Cu treatment levels, especially at 800 μM Cu, and Cu accumulated mainly in the roots of E. Argyi and E. Splenden, rather than in the shoots. However, up to 40% and 50% of its Cu adhered to the root surfaces of E. Argyi and E. Splenden, respectively. Root length and volume of E. Splenden had a positive response (P<0.05) to Cu concentrations; while E. Argyi did not.

Keywords: Cu toxicity, *Elsoltzia* species, Root morphology.

* Yuangen Yang, University of Georgia, AESL, 2300 College Station Road, Athens, GA
ygyang@uga.edu

16B

Ganjo, Dilshad

Phytoremediation of Wastewater Using *Typha domingensis* Persand*Saccarum strictum* (Host) Spreng

Dilshad Ganjo*, University of Salahaddin-Erbil; Dilshad Rasul, University of Soran

An outdoor investigation was conducted close to the main sewage canal of Erbil city, Northern Iraq. Removal efficiency of Pb, Cu, Cd and Ni in municipal wastewater was evaluated, using two local and cosmopolitan distributed aquatic macrophytes, namely; *Typha dominigensis* Pers and *Saccharum strictum* (Host) Spreng. Two experimental designs were tested; serial sand filtration pots (i.e. single, double and triple pots) implanted separately by unified number of each macrophyte and a constructed wetland implanted by both experimental macrophytes together. At the end of experimental period, which extended from April to Sep. 2012, heavy metal concentrations were analyzedin plants tissues (i.e. shoot and root systems), in addition to vertical profiles of sand in filtration pots and the constructed wetland. Furthermore, values of translocation factor (TF) and bio-accumulation factor (BAF) for both experimental macrophytes were calculated. Generally, results showed that; the constructed wetland, implanted with both macrophytes together showed much more removal efficiency for the studied heavy metals compared with sand filtration pots.The more replicated sand filtration pots the highest heavy metal removal efficiency was indicated. *T. domingensis* was more efficient in accumulating heavy metals in its shoot and root tissues compared with *S. strictum.* The root system of both macrophytes was more active in bio-accumulation of heavy metals than the shoot system. The calculated values of TF and BAF revealed that both plants can be classified as hyper accumulators for Pb and Cd, while they are classified as moderately accumulator category for Cu and Ni. Accumulation rate of heavy metals at 5 cm depth of filtration sand was much higher; always the lowest concentration was detected at the depth of 15 cm.

Keywords: wastewater, removal efficiency, heavy metals, *T. dominigensis*, *S. strictum*

* Dilshad Ganjo, University of Salahaddin-Erbil., Erbil, KRG **ganjo.science@gmail.com**

17B

Okoronkwo, Afamefuna

Bioaccumulation of Cadmium in Siam weed (*Chromolaena odorata*) and Node weed (*Synedrella nodiflora*): Impact of Ethylene diaminetetraacetate (EDTA) on uptake.

Afamefuna Elvis Okoronkwo*; Ademola Festus Aiyesanmi; Michael Sunday, The Federal University of Technology, P.M.B. 704, Akure, Nigeria.

In this study the translocation and accumulation capacity of *S. nodiflora* and *C. odorata* for Cadmium had been investigated. These plants have been effectively utilized for phytoremediation of cadmium contaminated soil. The impact of EDTA amendment on the remediation process had also been monitored. Results of the investigation showed that *S. nodiflora* had the capacity of up taking 86.25±1.91mg/kg of cadmium from the contaminated soil into the roots while uptake into the shoot amounted to 73.85±2.09mg/kg. *C. odorata* on its part was able to uptake 42.8±0.18mg/kg and 33.8±0.79mg/kg in its root and shoot respectively. The mobility of soil cadmium and the concentration of Cd in both plants were increased by EDTA amendment. EDTA application facilitated translocation of cadmium as the concentration in the roots and shoot of *S. nodiflora* increased to 104.9±7.07 mg Cd/kg and 77.02±0.99mg Cd/kg respectively. The effect of EDTA amendment was more pronounced on cadmium uptake by *C. odorata* as a value of 83.7±5.09 mg Cd/ kg in the root and 68.93±6.14 mg Cd/ kg in the shoot were accumulated. From this study, it was observed that despite the improved uptake by *C. odorata, S. nodiflora* appeared to be more suitable for phytoremediation of Cd contaminated soil.

Keywords: S. nodiflora, C. odorata, Cadmium (Cd), Ethylene diaminetetraacetate (EDTA), accumulation.

* Afamefuna Elvis Okoronkwo, Department of Chemistry, School of Sciences, The Federal University of Technology, P.M.B. 704, Akure, Nigeria. afamex @yahoo.com

18B

Nkrumah, Philip Nti

Incorporation of Phytotechnologies in Storm-Water Management in Developing Countries

Philip Nti Nkrumah*, College of Environment, Hohai University, China; Jingyu Huang, College of Environment, Hohai University, China; Desmond Ofosu Anim, College of Environment, Hohai University, China

Storm-water management is a major concern in most cities in developing countries. In recent times, the situation is worsened by the rapid urbanization coupled with ever increasing population growth in these cities which has resulted in increased impervious surfaces. As a result, the consequences of floods and water quality deterioration in cities such as Accra (Ghana), Beijing (China) and Jakarta (Indonesia) cannot be underestimated. The conventional approaches adopted in these cities in addressing the menace are costly, ineffective and unsustainable. This paper seeks to solely assess the feasibility of integrating phytotechnologies into the current storm-water management practices in developing countries. Hence, plant-based Low Impact Development (LID) techniques that infiltrate, filter, store, evaporate and detain runoff on-site as much as possible are explored in the present paper. The study also ascertained the benefits that could be derived from such technologies when applied in developing countries. Extensive research works on LID techniques, especially the practices in developed countries, were analyzed for their applicability in developing countries. We observed that the kinds of phytotechnologies that could be incorporated into the current practices in developing countries include green roofs techniques, ecological landscaping as well as bioretention techniques such as rain gardens, biofilters, bioswales, and bioinfiltration practices. These technologies were found to be cost effective, environmental friendly, flexible, simple, adaptable as well as sustainable. This paper provides vital information that would help in addressing the storm-water management challenges in developing countries for sustainable development.

Keywords: phytotechnologies, low impact development, storm-water management, urbanization, developing countries

* Philip Nti Nkrumah, College of Environment, Hohai University, No. 1 Xikang Road, 210098, Nanjing, China. Email: philiponti1209@yahoo.com

19B

Ahmadpoue, Fatemeh

Evaluation of Cadmium Bioaccumulation and Translocation in *Jatropha curcas* Grown in a Contaminated Soil

Fatemeh Ahmadpoue*, Pars Special Economic Energy Zone and Islamic Azad University; and Parisa Ahmadpour Boushehr Maritime Rescue and Environmental Protection Department and Universiti Putra Malaysia

Cadmium (Cd) is a metal with high toxicity and solubility in water which is a serious environmental pollutant to human health. Phytoremediation is a promising new technology that uses plants to clean contaminated areas and it is known as a low cost and environmental friendly which can be used to clean up heavy metal contaminated soils. This study was conducted to evaluate the potential of *Jatropha curcas* for remediation of soils contaminated with Cd. *S*eedlings were planted in soil spiked with Cd in amount of 0, 25, 50, 75, 100 and 150 mg kg^{-1} ($Cd_{0,}$ Cd_1, Cd_2, Cd_3, Cd_4 and Cd_5) for a period of five months. The highest growth performance was recorded in control (Cd_0). Cd concentrations among plant parts were in the following trend: roots>stems>leaves. In order to evaluate the potential of species selected as phytoremediator, three indicators were used namely, bioconcentration factor (BCF, metal concentration ratio of plant roots to soil), translocation factor (TF, metal concentration ratio of plant shoots to roots) and removal efficiency (RE, total concentrations of metal and dry biomass of plants to total loaded metal in growth media). The highest total Cd concentration (1125.68 ± 42.13 mg kg^{-1}) and total Cd removal based on total dry biomass (1.17 ± 0.08%) were found in Cd_5 and Cd_1, respectively. *J. curcas* showed high bioconcentration factor (BCFs>1) and low translocation factor (TFs<1). Hence, it may be inferred that this species has a potential to be used in phytoremediation of Cd-contaminated soil.

Keywords: phytoremediation, Cadmium (Cd), *Jatropha curcas,* translocation factor (TF), bioconcentration factor (BCF)

* Fatemeh Ahmadpoue, Moddaress street, Maryam 17 alley, No 14, Post code: 7516638511- Boushehr- Iran, fatima.ahmadpour@gmail.com

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Jadhav, Jyoti

Horizontal sub-surface flow phytoreactor for the remediation of a real textile effluent by combined system of efficient plants and their rhizospheric bacteria

Jyoti Jadhav* SUK India, Anuprita Watharkar SUK, Rahul Khandare SUK, Sanjay Govindwar SUK

Considering fluctuations in the hydraulics and dye contamination load at the site of actual textile effluent release, we have developed a horizontal sub-surface flow constructed phytoreactor. The potential plants-bacteria synergisms of *Petunia grandiflora*, *Portulaca grandiflora*, *Zinnia augustifolia,Typhonium flagelliforme* and *Tagetes patula*, *Pogonatherum crinitum* with their rhizospheric bacteria like *Bacillus pumilus strain* PgJ, *Pseudomonas putida* strain PgH,*Exiguobacterium aestuarii* strain ZaK were used. Complete decolorization of a real textile effluent within 48 h was seen in the consorial system while individually plant and bacterium took more than 48 h individually. Significant reduction in COD, BOD, TOC and ADMI values of real textile effluent was observed. Plants *Pogonatherum crinitum* and *Petunia grandiflora*, *Portulaca grandiflora* and *Tagetus patula*, *Zinnia augustifolia*, *Typhonium flagelliforme* showed noteworthy induction in the activities of enzymes laccase, tyrosinase, Lignin peroxidase, veratryl alcohol oxidase respectively while bacteria showed highest induction of riboflavin reductase, veratryl alcohol oxidase, DCIP reductase and azo reductase, indicating their major and combined role during biodegradation of textile effluent. Differential enzymatic machineries from plants and bacteria could achieve efficient and enhanced degradation and thus better treatment synergistically. The progressive degradation patterns of the textile effluent into different metabolites were analyzed using high performance thin layer chromatography and fourier transform infra red spectroscopy. The non-toxic nature of the metabolites of textile effluent degradation was revealed by subsequent phytotoxicity and cytogenotoxicity analysis.

Keywords: phytoreactor, phytoremediation, rhizospheric bacteria, cytogenotoxicity, constructed wetland

* Jyoti Jadhav, Department of Biotechnology, Shivaji University, Vidyanagar., Kolhapur, jpj_biochem@unishivaji.ac.in

21B

Wu, Longhua

Repeated phytoextraction of four metal contaminated soils by *Sedum plumbizincicola*, a Cd/Zn hyperaccumulator

Zhu Li, Longhua Wu*, Key Laboratory of Soil Environment and Pollution Remediation, Institute of Soil Science, Chinese Academy of Sciences

To understand soil heavy metal phytoextraction process, a Cd/Zn hyperaccumulator *Sedum plumbizincicola* was used to extract metal from four contaminated soils for seven crops during three years. Cd/Zn uptake by plant, *aqua-regia*, 0.01 M $CaCl_2$, 1M NH_4OAc, and diffusive gradients thin-films (DGT) extractable metal fractions were measured to investigate the dynamics plant metal uptake and soil metal concentrations during repeated phyto-extraction. The results showed that *Sedum plumbizincicola* the “average metal day-uptake”[#] in plant shoot of each crop decreased with the increase of remediation times for high metal level in acid soils, but kept “constant” for Cd in low polluted level of acid soil, and for Cd/Zn in alkaline soils, for the later phenomenon could be related with no big change of metal desorption rate from soil solid fractions in the phytoextraction process; after phytoextraction both total and available metal had great decreased, the decreases of acid soils were larger than alkaline soils, and the decrease of available fraction larger than total; R value based on DGT and K_d (the ratio between metal in soil solution and extracted by 0.01 $CaCl_2$) suggesting the ability of metal resupply from solid fraction when metal in soil solution depletion was weak and had no obvious change in acidic clay soil (pH 4.32) after the phytoextraction, increased in acidic silt soil (pH 5.68), and the resupply was good in two alkaline soils but decreased after phytoextraction, which may indicate the final state of phytoextraction is low metal in soil solution and low resupply.

Keywords: remediation, metal availability, resupply, DGT

* Zhu Li, Longhua Wu, 71 East Beijing Road, Nanjing 210008, PR China, lhwu@issas.ac.cn

22B

Nascimento, Clistenes

Toxicity of cadmium in jatropha assessed by x-ray fluorescence

Clistenes Nascimento*, UFRPE; Marise Marques, UFRPE

Cadmium contamination in agricultural soils is a result of fertilizers and wastes application and and presents serious consequences to animal and human health. The revegetation of Cd contaminated areas using non-edible crops can be an alternative to both immobilization of the metal and remediation of such areas. Giving jatropha (*Jatropha curcas* L) poses a relative tolerance to heavy metals and potential to biofuel production, the work was carried out to study Cd toxicity and photosynthetic stress assessed by x-ray chlorophyll fluorescence as well as the effects of Cd on the mineral composition changes, enzymes activity, soluble proteins and photosynthetic pigments. Jatropha plants were grown during 20 days in a nutrient solution with five Cd rates: 5, 10, 20, 30 and 40 µmol L^{-1} and a control with no Cd addition. Chlorophyll fluorescence was able to detect the alterations caused by Cd toxicity in plants. Jatropha posed tolerance to Cd and did not show effects on Fe contents and chlorophyll a in leaves. The plants displayed symptoms such as foliar chlorosis, biomass reduction, darkening and growth decreasing of root. Cd toxicity did not promote changes in enzymes with antioxidative activity and soluble protein contents in leaves. Jatropha is considered a promising crop for bioenergy production. It can also be used as an attractive alternative to vegetate contaminated areas with the economic advantage of commercial production of non-edible oil.

* presenting author,

23B

Lazo, Pranvera

Moss biomonitoring multi-elements atmospheric deposition study in Albania

Pranvera Lazo*, Faculty of Natural Sciences, University of Tirana, Albania, Trajce Stafillov, Institute of Chemistry, Faculty of Science, Sts. Cyril and Methodius University, Skopje, Macedonia, Marina Frontasyeva, Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Russia, Flora Qarri, Dept. of Chemistry, University of Vlora, Albania, Katerina Baceva, Institute of Chemistry, Faculty of Science, Sts. Cyril and Methodius University, Skopje, Macedonia, Zoya Goryainova, Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Russia, Lirim Bekteshi, Faculty of Natural Sciences, University of Tirana, Albania

Moss biomonitoring and ICP-AES analytical technique were applied to study multi-element atmospheric deposition in Albania. Mosses are suitable for monitoring trace elements in air. Analysis of the elemental content of mosses may give the opportunity to investigate whether toxic elements might be responsible for the health effects observed in epidemiological studies. Moss samples (*Hypnumcupressiforme*) were collected during the summer of 2011 and September – October 2010 from 62 sites evenly distributed over the country. Sampling was performed in accordance with the LRTAP Convention – ICP Vegetation protocol and sampling strategy of the European Programme on Biomonitoring of Heavy Metal Atmospheric Deposition. The concentrations of 19 elements including key toxic metals such as Pb, Cd, As, Ni, Cr and Cu were investigated. The contamination factor scale were used to interpret and to distinguish the contamination level of each element, while taking into account the method of dispersion of contaminants in the atmosphere. Cluster and Factor analysis was applied to distinguish elements mainly of anthropogenic origin from those predominantly originating from natural sources. Geographical distribution maps of the elements over the sampled territory were constructed using GIS technology. The median values of the elements for Albania were generally around the average median values observed in Europe through the European programme. The aim of this study was to provide a reliable assessment of air quality throughout Albania.

Keywords: moss biomonitoring; atmospheric deposition; trace elements; ICP-AES analysis; multivariate analysis, GIS technology.

* Pranvera Lazo, Department of Chemistry, Faculty of Natural Sciences, University of Tirana

24B

Lazo, Pranvera

Moss Biomonitoring for multielements atmospheric deposition study in Kosovo

Pranvera Lazo*, University of Tirana Kosovo and Albert Maxhuni, University of Prishtina

Biomonitoring is a means to detect the deposition, accumulation and distribution of trace metals in ecosystems, is the cheapest and simplest method for long term monitoring trace metal elements in the atmosphere. Mosses, as the particularly one of the main and effective biomonitors of atmospheric pollution, are geographically widespread, grow under different environmental conditions and are easy to handle. Their high action exchange capacity and high surface to volume ratio favor the accumulation of the large concentrations of heavy metals across the moss cell wall for long period.

For the first time the moss biomonitoring method and AAS-AES analytical technique were applied to study multielement atmospheric deposition in Kosovo. Moss samples (*Hypnumcupressiforme*) were collected during the summer of 2011 from 25 sites evenly distributed over the country. Sampling was performed in accordance with the LRTAP Convention–ICP Vegetation protocol and sampling strategy of the European Programme on Biomonitoring of Heavy Metal Atmospheric Deposition. 15 elements including key toxic metals such as Pb, Cd, and Cu were analyzed. Cluster and Factor analysis were applied to distinguish elements mainly of anthropogenic origin from those predominantly originating from natural sources. The median values of the elements for Kosovo were compared with those of Balkan countries and Norway selected as pristine area. This study was conducted in order to provide a reliable assessment of air quality throughout Kosovo, to produce information needed for better identification of pollution sources and improving the potential for assessing environmental and health risks in Kosovo, associated with toxic metals.

Keywords: Moss biomonitoring, atmospheric deposition, trace elements, AAS-AES analysis, multivariate anaylsis, pollution sources

* Pranvera Lazo, Department of Chemistry, Faculty of Natural Sciences, University of Tirana

25B

Peña-Salamanca, Enrique

Detoxification Mechanisms of Heavy Metals by Algal-Bacteria Consortia

Enrique Pena-Salamanca*, Universidad del Valle, A. Rengifo-Gallego, Universidad del Valle

Toxicity of heavy metals is apparent in reducing growth and development in microorganisms and plants. The basis for this biological disruption by metal activities is basically based on their ability to bind strongly to oxygen, nitrogen and sulfur atoms, due to their abundance in biological systems. An experiment to use microbial biomass associated with macroalgae for removal of heavy metals from aqueous solutions was developed. The trial was conducted in synthetic seawater with two levels of chromium, 5 and 10 mg/L, using bioreactors according to three treatments: microbial biomass alone, algal samples (*B. calliptera*, Rhodophyta, Rhodimeniales)with antibiotic, natural bacterial consortium, and the control without the presence of alga or bacteria. The experimental design followed a model of two factors (Concentration of chromium × Types of combination) with repeated measures using one factor. The behavior of microbial populations and the chromium decrease concentration percentage was monitored by using atomic absorption spectroscopy (AAS). Results showed greater bacterial growth at higher chromium concentrations (10mg/l) compared to those with the treatment exposed at 5 mg/l. Additionally, significant differences were obtained for both, bacterial population to the total concentration of chromium in the algae-bacteria systems. The algae–bacteria consortium was the most efficient treatment to remove the metal at the highest metal concentration, suggesting their active role in the transformation processes of this metal in aqueous marine solutions at environmental levels. Extensive surveys of heavy metal tolerant algal-associated bacteria are needed in order to obtain new data for biotechnological applications.

Keywords: heavy metals, red alga, *Bostrychia*, bacterial biomass, phytoremediation

* Enrique Pena-Salamanca, Universidad del Valle, Biology Department, Calle 13 #100-00 A:A 25360 Cali, Colombia. Enrique.pena@correounivalle.edu.co

26B

Deng, Yingqing

Uptake and accumulation of Nano-scaleTitanium oxide in rice plants

Yingqing Deng*, University of Massachusetts; Elijah J. Petersen, National Institute of Standards and Technology; Savelas Rabb, National Institute of Standards and Technology; Bryant C. Nelson, National Institute of Standards and Technology; Baoshan Xing, University of Massachusetts

Development and extensive use of engineered nanoparticles and their release to the environment and applications in agriculture have led to considerable concerns about safety issues of crops and vegetables. Therefore, the uptake of titanium dioxide nanoparticles (TiO_2 NPs) by rice plants was investigated over a ten-week period in hydroponic system. Five groups of rice plants were grown in aerated pots filled with modified Hoagland solution and the periodically exposed to TiO_2 NPs suspensions for 24 hrs per week in separate containers. The five treatments were deionized water, 5 ppm and 50 ppm TiO_2 NPs, 5 ppm bulk counterparts (TiO_2 BPs), and 50 ppm TiO_2 BPs. Titanium content in roots and shoots was determined through ICP-MS at time intervals of 1, 4and 10 week. Plants exposed to 50 ppm particle suspensions presented significantly higher biomass since the 4th week, showing TiO_2 could promote rice growth at this concentration. With increasing time, total titanium was found to accumulate in rice plants. The titanium concentration in shoot at 5 ppm and 50 ppm TiO_2 NPs was 9.17 and 6.08 µg/g, respectively, which were significantly higher than that treated with bulk particles. However both titanium concentrations and bioconcentration factors showed a distinct decreasing trend, revealing the rate of TiO_2 NPs uptake was slower than plant growth rate. These results implicate that TiO_2 NPs could be a risk to food safety and human health due to their potential plant uptake and accumulation.

Keywords: nanoparticles, plant uptake, accumulation, bioconcentration factor

* Yingqing Deng, 42 Stockbridge Hall, 80 campus center way, Amherst, MA
yingqing@psis.umass.edu

27B

El Mehdawi, Ali

Effects of Selenium Hyperaccumulation on Plant-Plant Interactions – Implications for Phytoremediation and Biofortification

Ali El Mehdawi, Colorado State University*; Elizabeth Pilon-Smits, Colorado State University.

Hyperaccumulators accumulate toxic elements to extraordinary levels. Selenium hyperaccumulators can contain 0.1-1.5% of their dry weight in Se, levels toxic to most other organisms. Selenium promotes hyperaccumulator growth and offers the plant several ecological advantages through negative effects on Se-sensitive partners. High tissue Se levels reduce herbivory, and high-Se litter deposition can inhibit neighboring plants. However, hyperaccumulators also offer a niche for Se-tolerant ecological partners, and even facilitate these partners through Se enrichment: their neighboring plants in the field have elevated Se levels, enhanced growth and reduced herbivory. Controlled plant-herbivore studies confirmed this protective effect of Se: high-Se neighbors of hyperaccumulators deterred grasshoppers and were toxic to them. Additional greenhouse co-cultivation experiments showed hyperaccumulators and nonaccumulators can affect each other's growth and Se accumulation. Through these combined negative and positive effects on ecological partners, Se hyperaccumulators may affect local species composition, favoring Se-tolerant species at different trophic levels. Furthermore, by sequestering and re-depositing Se in organic forms, Se hyperaccumulators may affect Se cycling through seleniferous ecosystems. These findings are useful for management of seleniferous areas and cultivation of Se-rich crops for phytoremediation or biofortification. Co-cultivation of crops with Se hyperaccumulators, for instance, may enhance Se phytoextraction efficiency and perhaps antioxidant activity. Pesticide application may be unnecessary since the crops are naturally protected by their accumulated Se. In the absence of Se-tolerant specialists, movement into the food chain does not appear to be a concern since herbivores tend to avoid high-Se plants. The same principles probably apply to other hyperaccumulated elements.

Keywords: selenium, phytoenrichment, allelopathy, cocultivation, herbivory

* Ali El Mehdawi, 1878 Biology Department, CSU, Fort Collins, CO; a_mezo_10@yahoo.com

28B

Ahmad Syed Shakeel

Phytoremediation potential of *Myriophyllum spicatum* in Hokersar wetland – a Ramsar site of Kashmir Himalaya

Syed Shakeel Ahmad*, University Of Kashmir, Zafar A. Reshi, University Of Kashmir, Manzoor A Shah, University Of Kashmir, Irfan Rashid, University Of Kashmir, Roshan Ara, University Of Kashmir,

Heavy metals are an important class of pollutants with both lethal and sub lethal effects on organisms. Wetlands are cheap natural alternatives for removal of heavy metals from soils; however, wetland plants vary greatly in their degree of metal uptake. Hokersar wetland, a Ramsar site of Kashmir Himalaya, India is a game reserve of international importance that provides suitable habitat for resident birds and an excellent stopover point for migratory birds visiting from Palaearctic breeding grounds in Central Asia, China, N-Europe and Siberia. The toxicity of chronic dietary metal exposure in birds may have adverse reproductive effects which include decreased egg production, decreased hatchability, and increased hatchling mortality. Thus, the present study aimed to assess the heavy metal sequestration capability of one of the most common wetland plant species *Myriophyllum spicatum* in Hokersar wetland. The accumulation of the different elements was in order of Fe> Al> Mn> Zn> Cr> Co> Pb> Cu> Cd >Ni. Translocation factor, i.e. ratio of shoot to root metal concentration revealed that Zn and Cu was greater than one. The translocation factor of Fe, Al, Mn, Cr, Co, Pb, Cd and Ni was less than one indicating the retention of these metals roots *M. spicatum*, thus reducing the supply of metals to marsh detrivores, avifauna, other bioaccumulators and surface waters. The enrichment factor for all the studied heavy metals was far greater than one. Translocation factor and enrichment factor for Cu and Zn was found to be greater than one. This indicates the potential of *M. spicatum* as an efficient hyper accumulator of Cu and Zn.

Keywords: Heavy Metal, *Myriophyllum spicatum,* Translocation,Sequestration, Phytoremediation.

* Syed Shakeel Ahmad, Department of Botany, University of Kashmir, Srinagar -190 006, J& K, India. E.mail: messahmad@rediffmail.com

29B

Singh, Vandana

Occurrence and distribution of endosulfan isomers in soil plant system of contaminated environment

Vandana Singh*, CSIR- NBRI Lucknow; Nandita Singh, CSIR- NBRI Lucknow

Endosulfan isomers and its metabolite endosulfan sulfate were studied in the soil and naturally growing vegetation of pesticide contaminated area, Ghaziabad, India. Soil and most dominating plants were collected at different point of contaminated area. Study revealed that soil of the studied area was contaminated with very high concentration of endosulfan isomers and its metabolite endosulfan sulfate (α endosulfan: 27-199 μg g^{-1} β endosulfan: 4-739 μg g^{-1} and endosulfan sulfate: 24-904 μg g^{-1}). Endosulfan isomers were present in almost all the plant samples while endosulfan sulfate was present in few samples. The concentration of total endosulfan in plant samples analyzed ranged from 14 to 343 μg g^{-1}. Among studied plants, *Vetiver zizanioides and Sphenoclea zeylamica* shows maximum and minimum accumulation respectively, with a significant difference at $p<0.01$ level. *Vetiver zizanioides and Chloris virgata* could accumulate considerable level of endosulfan isomers (343 and 163 μg g-1respectively) and endosulfan sulfate (20 and 2 μg g^{-1},respectively). The outcome of the study reflect the magnitude of test species in monitoring purposes and their potential for remediation of already contaminated sites.

Keywords: endosulfan, accumulation, persistence, monitoring, remediation

* Vandana Singh, Eco Auditing Group, National Botanical Research Institute, Rana Pratap Marg, Lucknow, 226001, India, nanditasingh8@yahoo.co.in

30B

Thangavelu Saravanan

Carbon sequestration efficiency in paddy soil and upland soil under long - term Fertilizer trials in Tamilnadu

Thangavelu Saravanan* Vanavarayar Institute of Agriculture, Pollachi

Soil organic carbon stock can be improved through the return of crop residues. However, the efficiency of C sequestered in soil might differ among cropping systems. In this paper, investigate the C input and SOC stabilization in paddy soil and upland soil under different long-term fertilization practices. Objectives were to determine (i) the response of SOC stock to C input under different fertilization practices, and (ii) C sequestration efficiency in the two contrasting agro ecosystems. The long-term fertilization experiment in paddy soil started in 2002, while the adjacent upland soil experiment commenced in 2005. Each experiment consists of 9 treatments: B (no fertilization), N, P, K, NP, NK, NPK, 2NPK (double dose), and NPKOM (NPK plus organic manure). Physical SOC fractions (cPOM, silt + clay_f, fPOM, iPOM_m, silt + clay_m) were isolated by sieving, dispersion, and density flotation. Fertilization increased crop yield and C input, but it did not change the quality of SOC. During the period of the experiment, SOC stock was improved by 6.7– 15.3 Mg ha1 in paddy soil for all fertilization practices, while in upland soil the B, N, P, K, and NP fertilizations reduced the SOC by 1.2–3.8 Mg C ha1 and the other four fertilizations increased it by 0.5 – 7.4 Mg C ha1. The change in SOC was mainly ascribed to the POM fraction, whereas the two silt + clay sized fractions were independent of fertilization practice except the NPKOM treatment. At a given C input, the C sequestration efficiency was greater in paddy soil than in upland soil, which may be attributed to lower microbial activity but greater chemical (i.e., oxalate-soluble Fe) and physical stabilizations (soil structure) in paddy field. Results indicate that paddy soil may sequester more SOC, with higher efficiency, than upland soil does.

Keywords: soil, sequestration, carbon

* Thangavelu Saravanan, Assistant Professor (Agronomy), Vanavarayar Institute of Agriculture, Pollachi, India. Pin 642103. thangavelusaravanan@hotmaail.com

31B

Lessl, Jason

Sparingly soluble P amendments enhanced phytoextraction of As by *Pteris vittata*, significantly lowering As from recalcitrant soil fractions over three years

Jason Lessl*, University of Florida and Lena Ma, University of Florida

Due to its unique ability to flourish in As-enriched environments, we evaluated the effect of As-hyperaccumulator *Pteris vittata* (PV) on soil-As redistribution over 3 years. From Dec. 2009 to Jan. 2013, PV grew in three As-contaminated soils amended with sparingly-soluble phosphate rock (PR-soil) or soluble P fertilizer (P-soil). In soils contaminated with 129, 25, and 30 mg kg^{-1} As, PV fronds averaged 1967, 614, and 588 mg kg^{-1} As, respectively which led to a subsequent decline of ~48% soil-As in PR-soils and ~38% in P-soils. Changes in soil-As sorption were determined by sequentially fractionating soils in order of decreasing plant availability: soluble, exchangeable, amorphous, crystalline, and residual. Labile As (soluble and exchangeable) accounted for ~16% of total As with the remaining non-labile As representing ~84% in all three soils. After 3 years, soluble As declined equally well in both treatments, with no change in the exchangeable fractions. In the non-labile As fractions, PV removed significantly more As from PR-soils than P-soils, averaging ~31% more from amorphous, 76% from crystalline, and 180% more from residual fractions. Plant uptake of As arises from labile fractions, so in an effort to acquire P from PR, PV would mineralize As from unavailable fractions, replenishing As in the exchangeable fractions during remediation. Using a model based on the ratio of As in unavailable to exchangeable fractions, frond As uptake by PV could be predicted. The low available P in PR-soils facilitated significant As removal from all soil fractions, potentially allowing for complete remediation.

Keywords: soil, arsenic, *Pteris vittata*, phytoremediation, sequential extraction

* Jason Lessl, University of Florida, 1102 NE 5th Pl., Gainesville, FL jlessl@ufl.edu

32B

Kumar, Pawan

Uptake and accumulation of CuO and ZnO engineered nanoparticles in carrot and parsnip

Pawan Kumar*, Southern Illinois University and Stephen Ebbs, Southern Illinois University

Extensive usage of engineered nanoparticles (ENPs) in recent years has raised concerns about their potential environmental risks. A limited amount of research has been done in the area of interaction of nanoparticles with plant systems and many gaps remain to be filled in the present understanding of this subject. Plants being the base of all ecosystems, there is a high possibility of ENPs entering the food webs and the human food supply. To provide an assessment of the potential risk of ENPs to plants, the proposed research will examine the interaction of CuO and ZnO ENPs with two food crops, carrot and parsnip. The mechanisms of ENP phytotoxicity are still not fully understood and there is a considerable need for investigation in this area. This research will characterize the accumulation of specific ENPs in two plant species (carrot and parsnip) and the phytotoxic effects on those plants. Efforts will also determine the spatial distribution of the ENPs in different plant tissues, primarily the edible tissues. The effect of ENPs on the growth and development of the plants will also be considered. In addition, attempts would be made to examine the possible biotransformations of the nanoparticles in the tissues. Overall, this work will provide information on ENP uptake and translocation to different tissues and mechanistic insight into phytotoxicity. The results will contribute to ongoing assessments of the hazard from consumption of these plant foods and the overall risks of ENPs to human health.

Keywords: plants, phytotoxicity, engineered nanoparticles

* Pawan Kumar, 420 Life Science II, 1125 Lincoln Dr., Carbondale, IL, 62901-6509, Southern Illinois University, Carbondale, ILpawank@siu.edu

33B

Selesky, Rob

Callus Cultures for Enhancement of Phytoremediation Traits in Aquatic Plants

Rob Selesky*, Michigan State University; Sam Schab, Michigan State University; Dawn Reinhold, Michigan State University; Shiny Mathews, Michigan State University;

Culture of plant calluses with exposure to toxic contaminants can induce a natural resistance. We have hypothesized that plants then regenerated from these calluses may inherit the ability to grow in environments with high levels of contaminants, thus enhancing their remediation capacity. Duckweed and juncus calluses were grown in media with increasing concentrations of trifluoromethyl- and fluoro- phenols. Monthly transfers to new media and periodic measurement of callus weight were performed to track growth and toxicity. After being treated with phenols, calluses were placed in regeneration media. Regenerated plants will be exposed to phenols in experimental reactors and aqueous concentrations of phenols with time will be measured using liquid chromatography-mass spectrometry. It is expected that plants regenerated from calluses exposed to phenols will more quickly uptake phenols.

Keywords: wetlands, remediation, pollutants, water, plant tissue culture

* Rob Selesky, 414 Michigan Ave., Apt E15, East Lansing, MI seleskyr@msu.edu

34B

Oh, Seungjin

A Study on the Development of Soil Neutrailizing-agent using Waste Materials (Waste-lime, Oyster, Bottom-ash)

SeungJin Oh*, Dept. of Environmental Engineering, The University of Seoul; Mihyeon Jo, Dept. of Environmental Engineering, The University of Seoul, Minah Oh, Dept. of Environmental Engineering, The University of Seoul, Chan-Oh Park, Korea Resource Corporation, Moon-ho Jung, Korea Mine Reclamation Corporation, Jai-Young Lee, Dept. of Environmental Engineering, The University of Seoul

The Soil pH is 5.8 ∼ 6.2 in Korea because of many factors including the geological structure and climate condition. There is known as the cause for soil acidification by weathering of the mineral, excessive use of the chemical fertilizer, and extensively diffused acid rain. The purpose of research is the advanced neutralization using environmentally-friendly material as waste resources against by acid soil. The physico-chemical property was analyzed to the acid soil and waste resource materials (waste lime, oyster shell, bottom Ash). The Batch-Test was performed under 3 stage. As a result, the experimental soil showed up about 3.19. Waste lime, oyster shell, bottom ash showed the alkalinity with 9.62, 10.08, 9.17 respectively. In case of the 1st Batch-Test experimental result, waste lime and oyster shell, the alkalinity was over 7.5 as good efficiency. On the other hands, the bottom Ash showed the pH 4 of the neutralization efficiency which is low. Waste resource materials to be applied to the 2nd step were chosen as the waste lime and oyster shell except the bottom Ash. In the 2nd Batch-Test, it was exposed to be the most appropriate in case of doing the combination ratio of the waste lime and oyster shell with 9 : 1. As the economical and effective aspect, combination ratio of the soil and materials was 9.6 : 0.6 with the 3rd step batch-Test experimental result.

Keyword : soil neutralization, waste lime, oyster, bottom ash, pH

* SeungJin Oh, 163 Siripdae-ro Dongdaemoon-gu, Seoul, Korea ohpromote@gmail.com

35B

Wang, Nan

Effects of simulated acid rain on soil respiration of *Cunninghamia Lanceolata*

Nan Wang***,** Zhejiang Agriculture & Forestry University;Shangbin Bai [2] Zhejiang Forestry College

In order to understand the impact of acid rain on soil respiration of *cunningghamialanceolata, a* field study with 3 simulated acid rain levels (pH2. 5, 4. 0 and6. 0) were conducted. Measurement of soil respiration was made using a LI-8100 soil CO_2 emission system, the soil temperature at 10 cm depth also was recorded. Results show that: (1) The soil respiration of *cunningghamialanceolata* under different acid rain levels fluctuated with distinct seasonal patterns and the soil respiration rate was influenced significantly by soil temperature. The mean rate of soil respiration under pH2.5 level were 1.79μmolm^{-2}s^{-1}, and increased 16% under control level (pH6.0) respectively. The mean rate of root respiration under pH2.5 level were1.03μmolm^{-2}s^{-1}, and increased 12% under control level (pH6.0) respectively.(2) Significant relationships between soil respiration and soil temperature at 10 cm under different acid rain levels of *cunningghamialanceolata* found, which could be best described by exponential equations. The regression equations had more predicative capability than those using only temperature as a single independent variable. (3) The Q_{10} (temperature sensitivity coefficient of soil respiration) values at pH2.5, 4.0 levels of *cunningghamialanceolata*were 1.40, 2.05, respectively. Compared withwhich at control level, theQ_{10} values tended to increase.

Keywords: simulated acid rain, soil respiration,*cunningghamialanceolata,* Q_{10} value

* Nan Wang, Agriculture & Forestry University, Hangzhou 311300, China
wangnan198110@163.com, [b]bshbin@21cn.com

36B

Aryal, Niroj

Potential of Poplar Plantations for Treating Food Processing Wastewaters

Niroj Aryal*; Dawn Reinhold, Ph. D, Michigan State University

Land application of high-strength, high flow food processing wastewater may result in anoxic and anaerobic soil environments. Metals like manganese, iron, and arsenic can leach under such conditions to pollute ground water, adversely affecting a major source of drinking water. Poplar plantations have potential to be a sustainable, low cost technology to increase the application rate of food processing wastewater to land without negatively impacting environment. This experiment used field and column studies to identify i) the inhibitory effects of application of food processing wastewater on poplar growth and ii) the effects of poplars on organic carbon and metal mobilization.

A total of 15 columns included 5 planted columns applied with food processing wastewater, 5 planted columns applied with water and 5 no-plant controls applied with wastewater. The plant used in the study was tall shade poplar trees var. *Populus deltoides* ×*Populus nigra* DXN 34. The results showed that the application of wastewater at the rate 1-2 times the highest application rate in practice did not decrease the growth of poplar plants. Poplar plants significantly decreased soil moisture from the soil than control with a crop factor of 3.86 ±0.6 indicating increased application of wastewater feasible for poplar plantation over existing land application rate. Poplar plants also had positive effect on degradation of carbon as compared to controls. Comparison of metal mobilization is under progress, but results show that arsenic concentration in stems and leaves of food processing wastewater applied plants was significantly greater than that of water applied plants. Data collection from an acre field site is also under progress. The presentation will cover the column as well as field experiments.

Keywords: Poplar, Food processing wastewater, metal mobility, arsenic, phytoremediation

* Niroj Aryal, 524 S. Shaw ln room 6, East Lansing, MI-48824, Email: aryalnir@msu.edu

37B

Grenier, Vanessa

Physiological and Transcriptomic Comparison of *Salix* Cultivars Used for Phytoremediation of Polluted Soils

Vanessa Grenier*, IRBV, Werther Guidi, IRBV, Julie Marleau, IRBV, Emmanuel Gonzalez, IRBV, Simon Joly, IRBV, Michel Labrecque, IRBV, Frédéric Pitre, IRBV

This research project is part of a larger multidisciplinary initiative called GenoRem (www.genorem.ca). GenoRem brings together many scientists from l'Université de Montréal and McGill University in a quest for understanding and developing the different mechanisms involved in phytoremediation. Eleven willows (*Salix*) cultivars are studied in the project. My work mainly tends toward the identification of willow cultivars that are particularly efficient, that produce high biomass yields, have rapid metabolisms and also have a strong tolerance to PAHs, PCBs and C10-C50 contaminates. In order to attain my objectives, an experiment containing 11 cultivars of *Salix* was installed in the summer of 2011 on a soil contaminated by the past activities of a former petroleum refinery. The summer of 2012 marked the first complete season where we were able to observe the growth of the individuals. Many different measures of physiological parameters (growth measures, stomatal conductance, dosing of leaf pigments, and measures of leaf surface) were taken throughout the season. Preliminary statistical analyses (ANOVA) revealed that some cultivars seemed to stand out from the others. *Salix sachalinensis* showed the best results for biomass production and *Salix purpurea* and *Salix nigra*were the best overall. In parallel, we are also doing RNA sequencing on the willows planted in the same experimental site in order to compare the expressed genes in the leaves which are potentially involved in the plant's response to soil contamination.

Keyword: phytoremediation, *Salix*, plant physiology, transcriptomic, soil

* Vanessa Grenier, 4101 Sherbrooke East, Montreal, Québec, Canada, vanessa.grenier@umontreal.ca

38B

Zhai, Guangshu

Cytochromes P450 are Enzymes to Hydroxylate 4-Monochlorobiphenyl in Whole Poplar

Guangshu Zhai*, The University of Iowa;Hans-Joachim Lehmler, The University of Iowa; Jerald L. Schnoor, The University of Iowa

Cytochromes P450 (CYPs) are potential enzymes to hydroxylate many xenobiotics and endogenous chemicals in living organisms, including plants. 4-Monochlorobiphenyl (PCB3) was found to be metabolized into five mono-hydroxylated PCB3 (OH-PCB3s) in whole poplars in previous work. However, the enzymes involved in the hydroxylation of PCB3 in whole poplars are still unclear. Therefore, two CYP suicide inhibitors, 1-aminobenzotriazole (ABT) and 17-octadecynoic acid (ODYA), were selected to probe the hydroxylation mechanisms of PCB3 in whole poplars. Poplars (*Populus deltoides* × *nigra*, DN34) were exposed to PCB3 with or without inhibitor for 11 days. Results showed both ABT and ODYA can decrease the concentrations and yields of five OH-PCB3s in poplar via the inhibition of CYPs. Furthermore, both ABT and ODYA demonstrated a dose-dependent relationship to the formation of OH-PCB3s in whole poplars. The higher the inhibitor concentrations, the lower the total yields of OH-PCB3s. In addition, the ratios of the total mass of different OH-PCB3s produced were also influenced by inhibitors and their concentrations. For example, the total mass of isomers on the opposite ring (2'OH-PCB3, 3'OH-PCB3 and 4'OH-PCB3) divided by the isomers on the chloro-ring (2OH-PCB3 and 3OH-PCB3) showed a monotonic increase with ABT concentrations. All results pointed to the conclusion that CYP enzymes were the agents which metabolized PCB3 into OH-PCB3s in whole poplars because suicide CYP inhibitors ABT and ODYA both led to sharp decreases of OH-PCB3s formation in whole poplars.

Keywords: Cytochromes P450, 4-Monochlorobiphenyl, Poplar, inhibition, hydroxylation

* Guangshu Zhai, 4105 Seamans Center, University of Iowa, Iowa City, IA, 52242
E-mail: zhai-guangshu@uiowa.edu

39B

Maestri, Elena

Proteomics of poplar for characterising response of clones to cadmium

Davide Imperiale, University of Parma; Marta Marmiroli, University of Parma; Elena Maestri*, University of Parma; and Nelson Marmiroli,University of Parma

Poplar species, hybrids and clones are considered ideal candidates for phytoremediation, also for phytoextraction of metal contaminants from polluted soils. Assessing and describing the differences in performance, considering the vast range of possible plants suitable for application, can be a problem. Our aim has been the application of proteomics, genomics and electron microscopy analysis to identify objective descriptors of individual clones and hybrids, identifying potential markers of tolerance and accumulation.

A contrast was drawn between the performance of clones 58-861 and Poli (*Populus nigra*) and A4A (*P. euramericana*, a *P. nigra* x *P. deltoides* hybrid). Differences in their tolerance to Cd exposure and the uptake, accumulation and translocation of Cd were noted following the hydroponic exposure of rooted cuttings to 20 μM $CdSO_4$ for either 48 h or 14 days. The hybrid clone A4A was the least affected by Cd exposure. Cd uptake and root to shoot translocation were determined by atomic absorption spectroscopy, and its compartmentalization was analyzed using SEM/EDX. A comparative proteomic approach through 2D liquid chromatography and MALDI-TOF mass spectrometry was undertaken to identify proteins differentially expressed in the treatment conditions. Several stress response proteins were induced upon Cd treatment, whereas metabolic and photosynthetic enzymes were repressed. A comparison with proteins evidenced in other phytoextractor plants and metal hyperaccumulators did not evidence obvious simiarities.

Keywords: Salicaceae, proteomics, cadmium, metal accumulation

* Elena Maestri, Parco Area delle Scienze 33A, 43124 Parma, Italy elena.maestri@unipr.it

40B

Marmiroli, Marta

Inorganic arsenic uptake and translocation in cultivars of tomato (*Solanum lycopersicum* L.)

Veronica Pigoni, University of Parma;Marta Marmiroli*, University of Parma; and Nelson Marmiroli, University of Parma

Arsenic, a metalloid occurring worldwide, is toxic and carcinogenic to humans. Plant uptake may create a pathway for As entry into the human food chain through. Genetic differences in As uptake and translocation to edible parts can justify the selection of specific cultivars or genotypes of some crop plants. *Solanum lycopersicum* L. (tomato) is frequently consumed in Europe and in Italy, representing an economically important cultivation. Due to the presence of As in irrigation water and soils, it is of interest to evaluate the mobility of As in the plant under different agronomic practices. The present study aims to evaluate the effects of agronomic practices on uptake and translocation of inorganic arsenic species (As III and As V) in different tomato cultivars: Aragon, Frigio, Gladis; The effect on arsenic toxicity of the application of silicates, normally used to improve stress resistance, was first tested by evaluating seed germination in vitro. Subsequent tests assessed arsenic concentration in roots, leaves and fruits of the selected cultivars combining treatments with As and Si.

In the cultivars Frigio and Gladis the concentration of As was less than in Aragon in all the plant parts. In fact the photosynthetic performance of these two cultivars was far better than that of Aragon under stressful conditions. In most treatments, the presence of Si increased uptake and translocation of As to aerial parts of the plants and also to the fruits. Differences among cultivars can be correlated with genetic relatedness.

Keywords: arsenic contamination, food safety, silicon, tomato

* Marta Marmiroli, Parco Area delle Scienze 33A, 43124 Parma, Italy – marta.marmiroli@unipr.it

41B

Ma, Xingmao

Differential Phytotoxicity, Distribution and Subcellular Localization of Silver in Different Chemical States

Bryan Quah Kah Ming, Southern Illinois University Carbondale; Jason C. White, Connecticut Agricultural Experiment Station (CAES); Xingmao Ma*, Southern Illinois University Carbondale

Metallic nanoparticles (both metallic oxide nanoparticles and elemental particles) are increasingly used in industrial manufacturing and previous research has demonstrated that metallic nanoparticles can exert both acute and chronic toxicity on plants and can be accumulated in plant tissues. Among all metallic nanoparticles, silver is among the most heavily examined particle for its phytotoxicity. It is well recognized that silver nanoparticles release ions through dissolution which are known to be phytotoxic. Consequently, there has been much debate regarding the nature of the phytotoxicity of silver nanoparticles (e.g. ion release through dissolution or generation of reactive oxygen species by silver nanoparticles). This study aimed to investigate the impact of different chemical states of silver (ionic, nanoparticles, and bulk) on phytoxicity to two agricultural crop species: *Glycine max* (soybean) and *Triticum aestivum* (wheat) and also to address the underlying mechanisms of toxicity. Silver distribution in different plant tissues and subcellular localization in different cell structures were also investigated. The results suggest that silver at different chemical states displayed differential toxicity to these two plant species, with ions exerting the strongest negative effect on plant root development at equivalent concentrations. All forms of silver were accumulated in plant tissues; however, morphology and distribution patterns within the plants varied greatly with chemical state.

Keywords: Silver, Wheat, Soybean, Nanoparticles

* Xingmao Ma, Department of Civil and Environmental Engineering, Southern Illinois University Carbondale, 1230 Lincoln Drive, Carbondale, IL, 62901, ma@engr.siu.edu

42B

Zhang, Weilan

Uptake and Accumulation of Cerium Oxide Nanoparticles by Radish in Hydroponic Systems

Weilan Zhang* Southern Illinois University Carbondale; Stephen Ebbs, Southern Illinois University Carbondale; Xingmao Ma, Southern Illinois University Carbondale

Foodsafety issues have increased dramatically due to the agricultural pollution. Engineered nanomaterials (ENM) that are broadly used in industry and are increasingly perceived as an emerging concern for food safety. However, the uptake and accumulation of these nanomaterials by plants is poorly understood. Even though below ground vegetables possess the highest potential to accumulate engineered nanomaterials in their tissues, almost no previous research has adopted belowground vegetables to investigate the potential uptake and accumulation of ENMs by food plants. In this study, young radish seedlings were grown hydroponics in quarter strength Hoagland solutions containing 0, 10 or 100 mg/L of cerium oxide nanoparticles, bulk powders or cerium chloride ions for four weeks until the radish fruit is about 1 cm in diameter. During the experiment, the transpiration rate, relative chlorophyll content and chlorophyll fluorescence as the F_M/F_V ratio were monitored as indicators of plant physiological status. At harvest, fresh and dry biomass of plant roots, edible root tissues and leaves were determined and cerium content quantified. The cerium state and distribution in radish fruit was analyzed with a Scanning Electron Microscope (SEM) and confirmed by SEM-EDX analysis. This investigation of cerium oxide accumulation and distribution in radish provides a critical frame of reference to evaluate the effects of ENMs on food safety.

Keywords: Nanoparticles, Hydroponically-grown, Radish, Cerium Oxide

* Weilan Zhang, Department of Civil and Environmental Engineering, Southern Illinois University Carbondale, 1230 Lincoln Drive, Carbondale, IL, 62901, Weilanzhang@siu.edu or ma@engr.siu.edu

43B

Abhilash, P.C.

Linking Bioremediation with Biomass and Biofuel Production

P.C. Abhilash*, IESD, Banaras Hindu University

Soil is an important life supporting system. But it is fragile and can easily be damaged by human interventions. So there is a huge cry for the protection of this most precious resource for food production and supporting the vital functioning of biosphere. It is estimated that about 30% land has been degraded/contaminated by various human activities. Apart from the contemporary pollutants (pesticides, heavy metals and hydrocarbons), the IT revolution and latest industrialization has accelerated the release of new generation of persistent organic pollutants. Because of their very long persistence and volatility, once released into the environment, they can redistribute and partition into various system through different process such as volatilization, leaching, global atmospheric transport, global marine transport. Therefore, there is an urgent need to protect our soil resource from further damage and remediate and restore already contaminated soils. Although a lot of chemical and engineering based approaches are being widely pursed for the remediation of contaminated soils, plants and associated microbial mediated remediation is getting wider popularity because of its cost effectiveness, sustainability and environmental implications. Furthermore, growing plants on contaminated sites will provide additional benefits like soil carbon sequestration, soil quality improvement, biomass and biofuel production, aesthetic appearance, biodiversity maintenance etc. Most importantly, the successful utilization of such degraded land for biomass and biofuel production will retain better arable land for food crops and will provide an additional income to poor farmers. The present lecture was aimed to present some factual cases describing the multipurpose benefits of phytoremediation

Keywords: bioremediation, soil carbon sequestration, biomass and biofuel production

* P.C. Abhilash, Institute of Environment & Sustainable Development (IESD), Banaras Hindu University, Varanasi 221005, India, pcabhilash@hotmail.com

44B

Comino, Elena

Riparian restoration: anthropized wetland versus natural wetland

Elena Comino*, Faculty of Engineering Torino (It); Maurizio Rosso Faculty of Engineering Torino (It);

The riparian wetland have many different functions, e.g. floodplain, river flow regulation, biodiversity conservation, filter system.., and all of them have the same relevance. This is much more true if the wetland is in non-urbanized regions, as well as in mountain regions. In mountains valley, due to the scarcity of free areas, the riparian zone are mainly occupied by human activities, e.g. agriculture or anthropic settlement.

Due to this conflict between different lands uses there is a growing need for an integrated approach in the restoration areas management in order to meet ecological/ hydrogeological and public needs.

The paper presents the work done to regain to naturality an area occupied by unauthorized settlement (camping site) since more than 15 years.

The designed “new wetland” would serve as buffer zone between the river and the agricultural land and to meet the needs of the population, but with awareness. For this reason the project include a didactical and cultural trail as well a reallocation of the camping site.

The study area is located on the left bank of the Pellice torrent, a 60 km length Italian alpine river, tributary of the Po River, which flows through the Province of Turin receiving the waters of several other torrents.

To develop the project, the authors have collected and elaborated ecological and hydrogeological data, from database as well as from in situ survey, implemented hydraulics numerical models and involved the collaboration of the landowners and community member.

This research is part of an Interreg project, TT:CoCo, in the Alcotra programme 2007-2013.

Keywords: riparian restoration, natural wetland, alpine river,

* Elena Comino, *Politecnico di Torino, Department of Land, Environmental and Infrastructure C.so Duca Degli Abruzzi, 24 – 10129 Torino ITALY elena.comino@polito.it

45B

Pierce, Samuel C.

Effects of Wetland Plants on Soil Redox Potential

Samuel C. Pierce*, Mississippi State University Department of Wildlife, Fisheries, and Aquaculture

Soil redox potential (Eh) is a major driver of wetland biogeochemistry and plant community composition. Although it is widely accepted that, under flooded conditions, wetland plants increase rhizosphere Eh, relatively few studies have addressed the potential plant-mediated responses of Eh in the bulk soil. This presentation summarizes a series of experiments that demonstrate plant effects on bulk soil Eh, measured using platinum electrodes. These experiments demonstrate:

1. There are species-specific impacts of plants on Eh.
2. Eh of flooded soils with live plant roots can be increased by providing drained soil to a portion of the plant's root system.
3. During senescence, planted soils may demonstrate significantly lower Eh than unplanted soils.
4. Plants may alter temporal and spatial variability in Eh.

The results of these studies are discussed in the context of their potential impacts on aquatic eutrophication, metal speciation, and constructed wetlands. This line of research clearly demonstrates that plants affect oxidation-reduction reactions beyond the immediate rhizosphere, and that this effect is not a simple increase in bulk Eh.

Keywords: wetland, Eh, redox, macrophyte

* Samuel C. Pierce, 512 Col. John Kelly Rd. Lewisburg, PA dr.samuel.c.pierce@gmail.com

46B

Sauer, Nancy E.

Growth and Survivability of Poplar Trees Exposed to LNAPL
Bench Scale Test

Littrell, Lori, BP Corporation; Tsao, David, BP Corporation, North America, Inc; Sauer, Nancy E.*, URS Corporation, Chintella, Larry, URS Corporation

The L-5 Landfill contains a liquid collection system to maintain an inward gradient from an adjacent river. As part of an evaluation of the use of poplar trees to provide natural hydraulic control within the landfill, bench testing was conducted. The objective of the testing was to evaluate the impact of LNAPL and groundwater on the growth and survivability of poplar trees. Three hybrid poplar clone varieties were grown onsite. Bare root poplar trees were shipped to the site and planted in containers. Trees were grouped in three groups containing trees of each clone. Monitoring and watering was conducted weekly. The trees were watered as follows:

- Group A – groundwater and LNAPL.
- Group B – groundwater without LNAPL.
- Group C – water obtained from the river.

Group B and Group C exhibited the best growth, indicating that the groundwater would not have a negative impact in tree growth provided LNAPL is not present. Group A exhibited significantly less growth. None of the trees exposed to LNAPL exhibited signs of stress. The observations indicate that the presence of LNAPL may result in slower growth but not fatality in the quantities applied.

Overall, the DN-34 clone exhibited significantly better growth than the other two clones. In the group of trees exposed to LNAPL the MI-88 and NE-58 clones exhibited better growth, indicating that the DN-34 clone may be more suitable for local conditions but that the other clones may be more tolerant of LNAPL.

Keywords: Natural Hydraulic Control, Poplar Trees, LNAPL

* Sauer, Nancy E.*,, 1375 Euclid Ave., Suite 600, Cleveland, Ohio 44115 nancy.sauer@urs.com

47B

Sauer, Nancy E.

Sustainable Wastewater Treatment at the Boston Mills Historic District
Cuyahoga Valley National Park, Brecksville, OH

Popielski, Janet, Cuyahoga Valley National Park; Sauer, Nancy E.*, URS Corporation

The Boston Mills Historic District in Cuyahoga Valley National Park is listed in the National Register of Historic Places as a significant intact example of a 19th-century "canal village" for its concentration of intact 19th century architecture. On the banks of the Cuyahoga River, it is adjacent to the historic Ohio & Erie Canal Towpath Trail and Valley Railway. Several alternatives were evaluated to address wastewater needs of the buildings in the Boston Mills District while preserving the cultural and natural resources of the park. An Environmental Assessment was completed (2009), resulting in a constructed treatment wetland being selected as the environmentally preferred alternative.

The constructed treatment wetland has a design flow of 10,000 gpd and consists of:

- Septic tanks
- Flow equalization
- Subsurface flow wetland initially planted with Blue Flag Iris, Green Bulrush, River Bulrush, Duck Potato, and Prairie Cordgrass
- Three tiered free water surface wetlands (evapotranspiration/infiltration)
- Recirculation

Using phytoremediation to achieve water quality standards, constructed wetlands provide a cost-effective alternative to traditional wastewater treatment while providing consistent and predictable performance. Advantages include lower capital costs, less long term maintenance, no generation of hazardous by-products requiring further treatment, high public acceptance, and less energy requirements. The treatment wetland system was brought on-line in 2011. Monitoring results confirm that the system has met treatment goals and permit limits. The wetland system has proven to be a sustainable alternative that is complimentary to the mission of the CVNP to protect and preserve the Cuyahoga Valley and its resources.

Keywords: Constructed Wetlands, Sustainable Wastewater Treatment

* Sauer, Nancy E.*, 1375 Euclid Ave., Suite 600, Cleveland, Ohio 44115 nancy.sauer@urs.com

48B

Hadi, Fazal

Effective Phytoextraction of Cadmium Contaminated Soil by *Cannabis sativa* plant

Ayaz Ahmad, Department of Botany, University of Malakand, Pakistan; Nasir Ali, Department of Biotechnology, University of Malakand Pakistan; Fazal Hadi*, Department of Biotechnology, Faculty of Biological Science University of Malakand Pakistan

The present study was conducted to evaluate the effect of different fertilizers (NPK), sodium chloride (NaCl) and plant growth regulators (GA_3, IAA and Zeatin) on *Cannabis sativa* plant and phytoextraction of Cd contaminated soil. The treatments effects were also evaluated on free proline and phenolics production in plant tissues and its role in Cd phytoextraction. Hormones were applied to plants as foliar spray and fertilizers were added to soil in solution form. The Cd concentration in different plant parts was analyzed by atomic absorption spectrophotometer. It was found that cadmium contaminated soil significantly reduced the plant growth (root and shoot length) and dry biomass comparing C (control without Cd) with C1 (control with Cd). The fertilizers treatments showed the most significant increase in plant growth and biomass. Proline and phenolics concentration in plant tissues was found significant in all the treatments but the highest significant increase was recorded in plants treated with NaCl followed by fertilizers treatments. Proline level was found higher in leaves while phenolics level was high in roots of the plant. All the treatments increased the cadmium accumulation in plant tissues as compared to control C1. This increase was highly significant in fertilizers treated plants.

Keywords: Cadmium, growth regulators, salinity, proline, phenolics,

* Fazal Hadi, Department of Biotechnology, Faculty of Biological Sciences, University of Malakand, 18800, Chakdara, KPK, Pakistan. dr.fhadi@uom.edu.pk

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Yelikbayev, Bakhytzhan

Carbon Sequestration on reclaimed loess soils on the South-East of Kazakhstan

Bakhytzhan Yelikbayev*, Kazakh National Agrarian University, Department Soil Science and Ecology

Long-term field studies (1991-2012) were conducted at soil permanent study area located 18 km east of Almaty (MollicKastanozems), on concrete plots, which (in spring 1991) were filled with loess outcrops.At the beginning of micro-plot experiment establishment, the fresh less rock contained 0.24% of the common humus. A similar study three years after that demonstrated the humus increase in the 0-10 cm layer for all reclamation variants. 38 years after establishment of variant with loess rock in 1971, the common humus content has increased up to 1.89%, in the case of adding vermicompost at the rate of 27 t/hectare – up to 1.84%(2009). Other variants were in the intermediate position regarding this index.Carbon sequestration in the form of humus is more pronounced in the early years (1991, 1993) of soil formation. During 18 yeas of syngenetic soil formation (1991-2009), it was during these three years when more than half of total carbon was deposited. At the year of our experiment establishment, ration of humic acids to fulvic acids (Sha/Sf) in the loess rock from borrow pit was 0.26, and the share of nonhydrolyzable residue was 23.0%. Determinations of 2009 (18 years after) demonstrated more significant changes: further increase of the Sha/Sf ration (up to 1.17) on the variant with phyto-control and (up to 1.24) – on the variant with addition of vermicompost (27 tons/hectare).In the replantosols (technosols), formed under conditions of the permanent experiment at the Zailiy Alatau foothills, during 18 (38) years of soil formation, 16.4-24.6 tons/hectare of carbon were deposited in the 0-30 cm layer.

Keywords: carbon sequestration. soil formation, reclamation, humus, humin acids, loess, replantosols (technosols), vermicompost.

* Bakhytzhan Yelikbayev, Abai str.8, 050010 Almaty, Kazakhstan, Almaty, Kazakhstan
bakhytjan@gmail.com

50B

Cui, Shuang

Verbena hybrid Voss: an accumulator of Pb

Shuang Cui*, Liaoning Shihua University; Shanlin Zhao, Liaoning Shihua University, Ping Li, Liaoning Shihua University

Characteristics of accumulation and tolerance of lead (Pb) in Zinnia angustifolia Verbena hybrid Voss and Aclypha hispida Bum. F. were investigate to identify Pb-accumulating plants. In this study, pot culture experiment was conducted to assess whether these plants are Pb-hyperaccumluators or accumulators. The results indicated that the Pb enrichment factor (concentration in plant/soil) and Pb translocation factore (concentration in shoot/root) of these plants were principally <1 in pot culture and concentration gradient experiments. However, the PB concentration in Verbena hybrid Voss shots was higher than 1000 mg kg-1, the threshold concentration for a Pb-hyperaccumulator. Shoot biomass of Verbena hybrid Voss had no significantly ($p < 0.05$) variation compared to the control. Based on these results, only Verbena hybrid Voss could be identified as a Pb-accumulator.

Keywords: Pb-contaminated soil, Celosia cristata pyramidalis, Accumulator

* Shuang Cui, 1 West of Dandong Road, Wanghua Area, Fu Shun, Liao Ning
cslisa2002@yahoo.com.cn

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Espinosa-Hernandez, Vicente

Phytoremediation with Mexican Lupinus Species in the Central Region of Mexico City

Vicente Espínosa-Hernandez*, Eshan Muhammad, Universidad Politecnica deFrancisco I. Madero, Hidalgo, Mexico, C.P. 42650, Nancy, De la Cruz Landero, Universidad autónoma del Carmen, Carmen, Campeche, México, C.P. 24180.

The phytoremediation offers the benefits of being in situ, low cost and environmentally sustainable. The phytoremediation uses the capacity of certain plant species to survive in environments contaminated with heavy metals and organic substances while extracting, accumulating and inmobilizing or transforming the contaminants. Actually, lupinus species is starting to generated interest for phytoremediation of soils showing intermediate metal pollution. The study area is located on Sierra Nevada in the Tlaloc Mountain in the State of Mexico. The contaminated soils used were collected at petroleum field in Tabasco State, Mexico and unpolluted soil sample was obtained from the top 25 cm layer of a crop field at San Pablo Ixayoc, State of Mexico. *Lupinus uncinatus* Schldl and *Lupinus versicolor* seeds were obtained from the Tlaloc Mountain, in the Nevada Mountain Range, within the municipality of Texcoco, State of Mexico. The results obtained provide valuable information on metal availability in contaminated soils and offer an indication of the potential risk a metal may pose to a given soil environment, along with providing a basis for developing soil quality guidelines for the prevention, investigation and clean-up of soil metal contamination. The results of this study with Mexican Lupinus species will be relevant and can be considered for extracting heavy metals and can be utilized for the phytostabilization and revegetation of contaminated soils, specifically with Cd, Ni and Cu. However, further research is vital for comprehensive understanding of the mechanisms involved in the response functions of the Lupinus species to heavy metals stress.

Keywords: Lupinus, soils, heavy metals, phytoremediation, soil contamination, metal tolerance

* Vicente Espínosa-Hernandez, Espinosa-Hernández Vicente, Colegio de Postgraduados en Ciencias Agrícolas, Km 36.5 Ctra. México-Texcoco, Montecillo, Edo.de México, C.P. 56230, México vespinos@colpos.mx

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Pidatala, Venkataramana

Metabolomic and Proteomic Profiling of Vetiver Grass (*Chrysopogon Zizanioides*) Under Lead stress

Venkataramana Pidatala*, Michigan Tech University, Dibyendu Sarkar, Montclair State University, Rupali Datta, Michigan Tech University

Lead (Pb) contamination in residential soils and public places due to its prior use in paints is a serious concern in the United States. Children under six years of age are particularly vulnerable to lead toxicity due to ingestion and inhalation. Previous research in our lab has shown that vetiver (*Chrysopogon zizanioides*) is a hyperaccumulator of lead. Metal stress induces various metabolomic and proteomic changes in the plant systems. In this study, vetiver plants were subjected to various concentrations (0, 400, 800, 1200 mg/L) of lead for different time periods (0, 10 and 20 days) in a hydroponic set up. Quantitative metabolomic profiling was performed using 5500 QTRAP (LC/MS/MS) hybrid triple quadrupole mass spectrometer. Metabolites with significant changes were identified and metabolomic pathway analysis was performed. The major upregulated pathways were tRNA biosynthesis in both root and shoot, amino acid metabolism including glycine, serine, threonine, valine, leucine, isoleucine, arginine and proline in root. Total protein from root and shoot samples were resolved on two dimensional gel electrophoresis. Differentially expressed protein spots were analyzed using MALDI-TOF after trypsin digestion. Peptide mass data was searched using the Mascot search engine. Significance of the changes in metabolic pathways and the proteomic changes with respect to metal stress will be presented. Metabolomic and proteomic tools can provide insights into some of biochemical and physiological changes under lead stress, which would lead to a better understanding of the process of metal accumulation and tolerance by vetiver.

Keywords: Lead, Vetiver, Phytoremediation, Metabolomics, Proteomics

* Venkataramana Pidatala, Dept. of Biological Sciences, Michigan Tech University, Houghton, MI, 49931 ramana@mtu.edu

53B

Moseki, Baleseng

Possible Phytoremedial Plants of heavy metals from *BCL* Cu/Ni mine smelter, Selibe-Phikwe, Botswana

Taolo Tumediso, University of Botswana and Baleseng Moseki*, University of Botswana

This study aimed at determining the levels of selected heavy metals (Ni, Cu, Zn, Cd, Pb) in the stream bed soil and in two (2) plant species (*Cynodon dactylon* and *Cyperus polystachyos*)that grew on the streambed soil on the west of the Bamangwato Concession Limited (BCL) Cu/Ni mine, Selibe-Phikwe, Botswana. Soil and plant samples obtained on the South-west of Selebi-Phikwe Cu/Ni mine, were analyzed (root and shoots separately) using Flame Absorption Atomic Spectrometry(Varian Model SpectrAA 220). Bulk soil samples contained heavy metals with a concentration range between 0.035 to 33.612 mg/L and plant samples contained concentrations in the range of 0.104 to 90.560mg/L. In general *C. dactylon* and *C. polystachyos* exhibited higher amounts of Cu, Ni, ZN and Cd in the roots and shoot than in the soil. The only exception is the shoot of *C. polystachyos* which displayed lower amount of Cu in the shoot than in the soil. It appears that most of the heavy metals in *C. dactylon* are accumulated in the shoot compared to the roots, thus making it an ideal plant for phytoremediation remediation purposes.
The fact that more heavy metals mostly accumulated in the shoot than in the roots is further confirmed by the bioaccumulation factor (BAF) (BAF=metal conc. in plant tissue/metal conc. in soil). Except for Ni, *C. dactylon* exhibited a higher BAF in shoot than in the roots. On the other hand *C. polystachyos* displayed a higher BAF in shoots than in the roots for Zn, Cd and Pb. On the basis of these preliminary findings it can be concluded that *Cynodon dactylon* is more suited to act as a phytoremedial plant for heavy metals than *Cyperus Polystachyos*. This is based on the fact that *C. Dactylon*sequester more heavy metals in the shoot than in the roots.

Keywords: heavy metals, mine smelter

* Baleseng Moseki,Department of Biological Sciences, University of Botswana, Private Bag UB 00704, Gaborone, Botswana mosekib@mopipi.ub.bw

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Atabayeva, Saule

The Effectof Humic Acidson Lead Accumulation by *Agropyron Repens*L. andBiochemical Parameters

Saule Atabayeva*, Ayzhan Beisenova, Batyrbek Sarsenbayev, Saule Kenzhebayeva.
Al-Farabi Kazakh National University, Almaty, Kazakhstan

The effect of humic acids (HA) on the uptake of lead by quack grass plants was studied. Lead levels in the variant (Pb (1000 mg/kg + 2,5 g/m^2 HA) increased in the roots almost twofold and in the shoots - in 16 times. With increasing content HA (5 g/m^2) in the soil Pb content in the shoots increased by 27% in comparison with low concentration, but in the roots Pb concentration decreased by 40%, may be, at the expense of translocation of Pb to the shootsBiochemical parameters were studied with plants grown hydroponically in 5 variants 1-0 (control); 2 - 1 mM Pb (Pb1); 3 - 2 mM Pb (Pb2);4 - Pb1 + HA (0,5 mM); 5 - Pb2 + HA (0, 5 mM). Chlorophyll (Chl) *a* content decreased in all treatments. Content of carotenoids remained unchanged or increased. Proline content increased in the shoots in all variants and in the roots - about three-fivefold. Proline content in the variants was lower in the presence of HA in comparison with variants without HA. HA stimulated the Pb uptake and it translocation from roots to shoots. Lead caused decrease of Chl a content, but increased Chl b and carotenides, it might be adaptive reaction.Lead increased proline content about four-fivefold, this increasing roles as osmotic compatible and osmoprotector under heavy metals stress.

Keywords: lead, humic acids, chlorophyll, carotenoids, proline.

* Saule Atabayeva, 050040 Al-Farabi str, 71. Almaty, Kazakhstan , Atabayeva S.
sauleat@yandex.ru

55B

Kathavarayan, Veeramani

Chemical Immobilization of Nickel in Long Term Sewage Irrigated Soil

Veeramani Kathavarayan*, Vanavarayar Institute of Agriculture, India.
Avudainayagm Subramaniyan, Doraisamy, P., Chandraseharan, C.N. Tamil Nadu Agricultural University

Nickel is one of the trace elements commonly found in urban waste water. In India, often raw sewage water has been indiscriminately used for irrigating food chain crops. Irrigation of sewage water, having Ni at considerable level threatens to human health. Around 1.23 mg kg^{-1} ofaquaregia extractable Ni was analysed in sewage water. The experimental soil has Ni around 32.71 mg kg^{-1} irrigated with raw waste water for more than 65 years. The soil pH is slightly alkaline (7.57) and electrical conductivity of 0.57 dS m^{-1}. The soil Ni concentrations were studied for its water soluble and exchangeable form which is considered as bioavailable concentrations to crops. Water soluble and exchangeable forms of Ni were measured 0.27 and 2.06 mg kg^{-1} respectively in soils. To remediate Ni, two chemical immobilizers, $FeSO_4$ and $CaSO_4$ were used to arrest Ni mobilization in soil solution. To demonstrate this, a batch experiment was conducted with different doses of $FeSO_4$ and $CaSO_4$. Among the different doses, $FeSO_4$ 5% (w/w) was effective in decreasing the Ni concentration of both water soluble and exchangeable form than $CaSO_{4.}$ Subsequently, in pot culture experiment, crop uptake of Ni from the soil was lower at lower doses of $FeSO_{4.}$ The results shows that accumulation of Ni was higher in the roots of *Amaranthus dubius* and *Beta vulgaris* var. *bengalensis* than *Celosiaargentia* and *Tageteserecta* than shoots of the respective crops.

Keyword: Iron sulphate, Nickel, accumulation, leafy vegetables

* Veeramani Kathavarayan, C.N.Tamil Naduo Agricultural University, Tamil Nadu, India

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Zhongbing, Chen

Effect of tidal operation on pilot scale horizontal subsurface flow constructed wetland for the treatment of sulfate rich groundwater contamination by chlorinated hydrocarbons

Zhongbing Chen*, Peter Kuschk, Helmholtz Centre for Environmental Research, Leipzig, Germany

Three different flow regimes were undertake in a pilot scale horizontal subsurface flow constructed wetland (planted with *Phragmites australis*) treating sulfate rich groundwater contaminated with MCB (monochlorobenzene), (about 8 mg/L), and PCE (perchloroethene), (about 2mg/L). The three regimes were continuous flow, 7 days cycle discontinuous flow and 2.5 days cycle discontinuous flow. The results shows intensify tidal regime (2.5 days cycle) enhanced MCB removal significantly before 2m from inlet, and increase the removal efficiency of PCE at 0.5m. The dechlorination process was promoted with tidal operation, especially under the 2.5 days cycle regime, with significant increase of *cis*-1,2-DCE, VC and ethane, while *trans*-1,2-DCE was significantly decreased after tidal operation. Due to the high sulfate concentration in the influent, sulfide was observed in pore water with the concentration up to 20mg/L and 23mg/L under continuous flow and 7 days cycle regime, respectively. However, sulfide concentration was reduced significantly by intensify tidal operation. The increase in oxygen concentration in pore water through intensify tidal operation gives the explanation of better MCB removal performance and the successful inhibition of sulfate reduction. Therefore, intensify tidal operation was suitable for increasing MCB and inhibiting sulfate reduction.

Keyw**ords:** Chlorobenzene, constructed wetland, groundwater, perchloroethylene, helophyte

* Zhongbing Chen, 433300, Hubei, China zhongbing.chen@gmail.com

57B

Song, Jing

An overview of recent advance in research and development of phytoremediation of contaminated sites in China

Jing Song*, ISSCAS; Longhua Wu, ISSCAS

Over the past five years, phytoremediation, especially phytoextraction and phytostabilization of contaminated soils and mine tailings, remains a hot topic for research and technology development in China.

As of phytoextraction, several new metal accumulating or hyperaccumulating plants (mostly for Cd, others for Zn, Pb and Mn) were identified. Weed species are also among potential candidates. Although biological and physiological studies have been undertaken to characterize plant response to metals, metal uptake, transportation, and distribution, more work are still needed to understand the genetic and molecular mechanisms for detoxification and hyperaccumulation of the new hyperaccumulators. Antimony has become a new focus in As phytoextraction, some progress has been made with regard to competitions between As and Sb for plant uptake. Apart from field trials, the past fives years also saw a number of real applications of phytoextraction of As and Cd contaminated agricultural soils in different parts of China. As to phytostabilization, native metal tolerant species from the Gramineae, Compositae, Leguminosae, Polygonaceae and Cruciferae families have been selected. Some research have shown that plant biomass and coverage increase with increasing plant biodiversity at the mine waste dump. Apart from usual chemical stabilizing agents such as lime, hydroxyapatite, composts etc., rhizosphere bacteria AM fungi have also been screened and applied to promote plant growth and metal tolerance. Heavily contaminated soils which are not safe to grow edible crops are being used to grow ornamental trees, flowers or energy crops in large scale demonstration projects.

Keywords: phytoremediation R&D, China review

* Jing Song, No.71, East Beijing Road, Nanjing, 210008, P.R. China

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Hajabbasi, Mohammad Ali

Effect of sewage sludge on phytostimulation of petroleum hydrocarbons by maize (*Zea mays* L.)

Aboozar Asadolahi, Master Studednt of Soil Sciences, Isfahan University of Technology (IUT-Iran); Mohammad Ali Hajabbasi*, Professor of Soil Sciences, IUT-Iran; Mojgan Sepehri, Assistant Professor of Soil Sciences, IUT-Iran; Javad Zamani, PhD Student of Soil Sciences, IUT-Iran.

Phytoremediation is a promising technique for reclamation petroleum contaminated soils. Phytostimulation, an important mechanism involved in phytoremediation of petroleum hydrocarbons, is the degradation of petroleum hydrocarbons via stimulation of microorganisms in the root zone. In this study, the effect of sewage sludge application on degradation of petroleum hydrocarbons in a petroleum contaminated soil was investigated. Maize (*Zea mays* L.) was grown in three levels of sewage sludge (0, 2, and 5%) under controlled conditions. At the end of the experiment, total petroleum hydrocarbons (TPH), microbial respiration and dry weight of root and shoot were measured. The results demonstrated that maize could grow better in the presence of sewage sludge and thus more roots and shoots dry weight were observed at the presence of the highest level of sewage sludge application. The study observed that application of sewage sludge improved microbial respiration and resulted in faster TPH dissipation especially in the presence of the plants. According to these results, application of sewage sludge could enhance phytoremediation of investigated petroleum-contaminated soil.

Keywords: petroleum-contaminated soils, phytostimulation, maize (*Zea mays* L.), sewage sludge.

* Mohammad Ali Hajabbasi, Department of Soil Science, College of Agriculture, Isfahan University of Technology (IUT), Isfahan, 84156-83111 IRAN. hajabbasi@gmail.com

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Perrino Enrico Vito

A phytosociological study in multi-metal contaminated soils of a protected area in Southern Italy

Enrico Vito Perrino*, Botanic Garden Museum, University of Bari (Italy);Karam Farrag, Central Lab for Environmental Quality Monitoring (CLEQM), National Water Research Center, Egypt; Gennaro Brunetti, Department of Biology and Agroforestry and Environmental Chemistry, University of Bari, Italy.

A phytosociological study was carried out in the National Park of Alta Murgia, Apulia region south east of Italy, to determine the adverse effects of metal contaminated soils on the distribution of plant communities. The area has been identified as one of the Sites of Interest of the European Community (SIC) and the Special Protection Zones (ZPS). The analyses have shown a remarkable high plant biodiversity on non-contaminated soils and a very low one on metal-contaminated soils. The investigated area is naturally covered by a wide steppic grassland (*Acino suaveolentis-Stipetum austroitalicae*) dominated by *Stipa austroitalica* Martinovský subsp. *austroitalica*. Brassicaceae, such as *Sinapis arvensis* L., are the dominating species on moderated contaminated soils (*Roemerion hybridae*). Whereas spiny species of Asteraceae, such as *Silybum marianum* (L.) Gaertn.and*Carduus pycnocephalus* L. subsp. *pycnocephalus,* are the dominating vegetation (*Onopordion illyrici*) on heavily metal-contaminated soils. These native plant species that grow well on contaminated soils may suggest using them for restoring degraded lands as a phytostabilization strategy. The objectives of research were to: (1) identify soil metal contamination levels of the studied area in relation to Italian admissible metal limits; (2) determine which plant species are affected by metal contaminated soil; (3) establish relationships between degree of soil contamination and distribution of plant communities.

Keywords: Soil contamination, heavy metals, natural vegetation, phytosociology, phytostabilization

* Enrico Vito Perrino, via E. Orabona 4, 70126 Bari (Italy), enricoperrino@yahoo.it

60B

Rofkar, Jordan

A Bioberm for Remediation of Groundwater at the Site of a Former Manufactured Gas Plant

Jordan R. Rofkar*, University of Toledo; Daryl F. Dwyer, University of Toledo; William G. Petruzzi, Hull & Associates, Inc.

Historically, the process of recovering gas from coal during the coking process has introduced harmful by-products into the environment. During the redevelopment of a former manufactured gas plant (MGP) in Toledo, Ohio, we are designed and constructed a bioberm as part of a multi-faceted strategy for remediating localized groundwater. Here we present design and construction considerations, and initial results on remediation of cyanide and polycyclic aromatic hydrocarbons (PAHs). To isolate groundwater on-site and prevent its migration to an adjacent stream, a groundwater barrier wall was constructed. A portion of the water that collected behind the barrier was pumped into the bioberm – an aboveground, plastic-lined berm filled with high permeability substrate. Our system design allowed for comparison of two separate plant communities in terms of their effects on biodegradation processes. We selected native plant species that exuded oxygen to enhance aerobic biodegradation and/or organic carbon to encourage co-metabolism of contaminants by microorganisms in the subsurface. A local development group is constructing an office building on the site, which utilizes effluent from the bioberm for on-site irrigation and for flushing toilets. Success of this bioberm system will foster redevelopment of some of the hundreds of MGPs still undeveloped in the Midwest.

Keywords: cyanide, native plants, biodegradation

* Jordan R. Rofkar, 2801 W. Bancroft St., Toledo, OH; jordan.rofkar@rockets.utoledo.edu

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Nunez-Lopez, Roberto Aurelio

Rhizofiltration, leaching and electro-recovering of lead from water hyacinth (*Eichhornia crassipes*): an integrated eco-technology for the treatment of industrial wastewater

Roberto Aurelio Núñez-López*, CIDETEQ; Yunny Meas-Vong, CIDETEQ; Eugenia Olguin, INECOL

In this work is presented an integrated study which involves biological, chemical and electrochemical processes in order to treat waters polluted with lead using water hyacinth as a bioabsorbent plant. The research was carried out in three stages: i) bio-absorption, ii) leaching, and iii) electro-recovering. In the first stage it was determined that water hyacinth had an maximum Pb bio-absorption efficiency of 77.5%. In the second stage, it was used ammonium oxalate as leachant agent, starting from the hypothesis that besides to extract lead from the biomass this salt will enrich it with nitrogen compounds and therefore it would be used as fertilizer. It were compared two leaching processes: simple (one stage) vs sequential (two stages), determining an Pb extraction efficiency of 52% and 91% respectively. After leaching the amount of nitro-compounds, i. e. N-NH3, N-Org, N-Total of the leached biomass increased significantly. Finally, in the third stage, the Pb leached and concentrated in the leachate it was recovered by electro-deposit, achieving a maximum recovery efficiency of 95%.

Keywords: rizhofiltration, leaching, electrorecovering, lead, *Eichornnia crassipes*

* Roberto Aurelio Núñez-López, CIDETEQ. Parque Tecnologico Queretaro s/n. San Fandila, Pedro Escobedo, Queretaro, Queretaro, México, 76700. ndahi2010@yahoo.com

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Daley, Douglas

Hydrologic Performance of an Alternative Vegetative Cover Using Shrub Willows in Central, NY

Douglas Daley, SUNY ESF*; John McAuliffe, Honeywell International; Lawrence Abrahamson, SUNY ESF; Timothy Volk, SUNY ESF; Stephanie Lewis, SUNY ESF; Shun Shi, SUNY ESF.

A phased phytoremediation strategy using a shrub willow-based alternative landfill cover is being developed to reduce leachate generation on the former Allied-Signal Settling Basins in Camillus, NY. The goal of the project is to develop and deploy an effective vegetative cover that will reduce the percolation of chloride salts into groundwater and surface water and simultaneously produce a source of woody biomass as a renewable energy source. Following the addition of organic amendments to the Solvay process residues, a byproduct of soda ash production, shrub willow are planted directly into amended materials, yielding biomass production that meets or exceeds production on agricultural soils in the region. About 35 ha of this alternative vegetative cover have been deployed between 2008 and 2013. An ongoing program of monitoring and modeling the hydrologic performance has been underway since pilot-scale tests were first conducted in 2005. In spite of the humid Central New York climate averaging about 1000 mm of precipitation annually, sap flow sensors, wicking pan lysimeters, soil moisture and conventional meteorological methods have demonstrated the effectiveness of the dense canopy and root system of the willow cover system at promoting evapotranspiration and storage over a prolonged growing season. The net effect is to shift the water balance away from percolation. The demonstrated success of the project enabled the site owner to obtain regulatory approval to continue phased deployment and monitoring of the alternative landfill cover system.

Keywords: *Salix*, willow biomass, phytohydraulic control, water balance, water budget, hydrology

* Douglas Daley, 402 Baker Lab, SUNY ESF, 1 Forestry Drive, Syracuse, NY 13210; djdaley@esf.edu

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Kahlid, Rafia

Heavy Metal Removal from Wastewater using Aquatic Floating Macrophyte

Muhammad Arshad, Institute of Environmental Science and Engineering (IESE), (Faculty) Muhammad Arshad, National University of Sciences and Technology (NUST) H-12, Islamabad-44000, Pakistan; Rafia Khalid*, Institute of Environmental Science and Engineering (IESE), (Postgraduate student) Rafia Khalid, National University of Sciences and Technology (NUST), H-12, Islamabad-44000, Pakistan

Toxic metal pollution of water bodies is major environmental problem and has accelerated dramatically since the beginning of industrial revolution. Aquatic plants are known to accumulate metals and other toxic elements from contaminated water. This study was undertaken to investigate short term uptake of Cadmium by *Nasturtium Officinale* and its potential in phytoremediation technology. Plant was exposed to varying levels of Cadmium to assess accumulation and toxicity. Plant samples were analyzed for their heavy metal contents using Atomic Absorption Spectroscopy. The result of hydroponic experiment has showed decrease in chlorophyll content and biomass. On the whole metal uptake by the plant was dependent upon the concentration of the metal and the duration of exposure. Metal content in plants increased with the increase in metal concentrations in solution and the metal accumulation in shoots was significantly higher than that in roots. Watercress treated with 10 mg/L of Cadmium accumulated the highest concentration metal in shoots (3.04 mg/kg) and roots (1.52 mg/kg). The results also revealed that plant is Cadmium accumulator with TF >1 and BCF values ranges from 0.28 to 1.5. This study has also reported an interesting finding that there is no impact of metal contamination on amount of extracted oil from plant. Furthermore, XRF result of oil showed presence of essential elements K, Ca, Zn and Fe. Cadmium was not found in oil. Thus, Plant can be successfully used for removal of Cadmium.

Keywords: Water pollution, Heavy metal-Cd, Macrophyte, Bioconcentration Factor, Translocation factor, Oil-extraction.

*Rafia Khalid, CB 900, Mansehra Road P.O Jhangi. Abbottabad, KPK, Pakistan.
blessings_1001@hotmail.com

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Farrell, Molly

Application of Highly Unique Natural Plant Communities to the Restoration of an Industrial Waste Site

Molly L. Farrell, SUNY-ESF, Anthony S. Eallonardo, O'Brien & Gere, Donald J. Leopold, SUNY-ESF

Located in central New York near Onondaga Lake, the Natural Communities Restoration Project began in 2008 on a seasonally flooded, alkaline and infertile area (2.1 ha) of a much larger Solvay wastebed complex. The project goal was to plant native species adapted to site conditions on the wastebeds to establish ecological function and aesthetic, wildlife, natural heritage, and educational values. About 55,000 plugs and seeds from over 140 plant species of inland salt marsh, brackish marsh, wet meadow, marl fen, and alvar grassland plant communities of New York State were planted from 2008-2010; 262 vascular plant species have been observed on site since 2008. The total and relative cover of target species have been on a positive trajectory since 2008 while the relative cover of *Phragmites australis* has been on a negative trajectory. The relative cover of *Lythrum salicaria* had decreased significantly in the first three years of the project, but a historic and artificial spring flood in 2010 killed a number of cool season flood intolerant species, likely creating a spike in available resources to which *L. salicaria* responded. The decrease in the relative cover of *L. salicaria* between 2011 and 2012 suggests however, that the site is successfully recovering from this extreme flooding. Results indicate planting native species adapted to stressful growing conditions, such as those endemic to the marl fen and inland salt marsh plant communities, is a highly effective and relatively inexpensive method for restoring ecological function on highly degraded industrial waste sites.

Keywords: Native plant communities, site invasibility, habitat restoration, stress, Solvay settling basins

* Molly L. Farrell, 1 Forestry Dr., Syracuse, NY mofarrel@esf.edu

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Awotoye Olusegun

Phytoremediation potentials of selected indigenous tropical weeds in heavy metal contaminated soils under bioaugumentation

Omotola Dada, Joseph Ayo Babalola University,Olusegun Awotoye Obafemi Awolowo*, University

The study assessed the phytoremediation potentials of some selected West-African weeds in Cadmium and Lead contaminated soils under mycorrhizaaugmentation. Four West-African weeds (*Amaranthus spinosus, Euphorbia heterophyllaSida acuta* and *Synedrella nodiflora*) were selected and grown in soils spiked with two heavy metals (Cd and Pb) at five levels of concentrations each: 0 $mgkg^{-1}$, 20 $mgkg^{-1}$, 40 $mgkg^{-1}$, 60 $mgkg^{-1}$and 80 mgkgfor Cadmium and 0 $mgkg^{-1}$, 250 $mgkg^{-1}$500 $mgkg^{-1}$, 750 $mgkg^{-1}$and 1000 $mgkg^{-1}$ for Lead in a completely randomized design and replicated three times with *Glomusintraradices*, *G. mosseae* and non-inoculation. The plant growth were monitored fortnightly, harvested and dried at 12 weeks after planting (WAP) for the analysis of Cd and Pb concentrations in both soils and plant tissues using Atomic Absorption Spectrophotometer (AAS). The bio-concentration factor (BCF) of each weed was also determined.Data collected were subjected to analysis of variance and the means were separated using Duncan Multiple Range Test. The four West-African weeds *Amaranthus spinosus, Euphorbia heterophylla,Sida acuta* and *Synedrella nodiflora* exhibited high phytoremediation potentials in Cd and Pb contaminated soil under augmentation. Highest bioaccumulation factors of 9.0 and 10.5 were observed in *Amaranthus spinosus* inoculated with *Glomus intraradices* for both Cadmium and Lead above 1.00. In Cd and Pb contaminated soil-environment without augumentations, *Sida acuta, Synedrella nodiflora* and *Euphorbia heterophylla* accumulated 50% and 62% of Cd and Pb in roots with bioaccumulation factors less than 1.00. Inoculation of the weeds with *Glomus intraradices* and *Glomus mosseae*enhancedthe phytoremediation potentials of the weeds with improved bioaccumulation factors greater than 1.00. The study concluded that *Amaranthus spinosus* displayed the highest phytoremedial potential than other weeds.

Keywords: Phytoremediation, bio-concentration factor, weeds and augmentations

* Olusegun Awotoye Obafemi Awolowo, Institute of Ecology and Environmental Studies, Nigeria
segunawo@oauife.edu.ng

66B

Dada, Omotola

Heavy metal accumulations of some West-African weeds in a multi-metal contaminated soils of the tropics under bioaugumentation

Omotola Dada*, Joseph Ayo Babalola Universty, Olusegen Awotoye, Obafemia Awolow University

This paper presents the outcome of a study which investigated the hyperaccumulation of Cadmium (Cd) and Lead (Pb) by selected indigenous tropical weeds in a multi-metal soil-environment under the influence of two bioaugments. The experiment was conducted in a 288 m^2 plot on a waste disposal site of a paint industry in Southwestern Nigeria. Four selected weeds (*Amaranthus spinosus, Euphorbia heterophylla,Sida acuta* and *Synedrella nodiflora*) were planted in a randomized complete block design with three replicates under two treatments of mycorrhizal(*Glomus intraradices* and *Glomus mosseae*) inoculation and non inoculation; biomonitored fortnightly. At harvest (12 Weeks after Planting), Cd and Pb concentrations were determined in soils and plants from the three plots using Atomic Absorption Spectrophotometer (AAS).Data collected were subjected to analysis of variance and the means were separated using Duncan Multiple Range Test. Mycorrhizal inoculation enhancedthe phytoremediation potentials of the weeds with improved bioaccumulation factors and transfer factors greater than 1.00 observed in 75% of the weeds inoculated with *Glomus intraradices* for both Cadmium and Lead in the contaminated soils. Highest bioaccumulation and transfer factors (2.53 and 2.24) were reported in *Amaranthus spinosus* inoculated with *Glomus intraradices.* However, without mycorrhizal augumentations, *Amaranthus spinosus*, *Sida acuta, Synedrella nodiflora* and *Euphorbia heterophylla* accumulated Cd and Pb in roots more than in the shoots with bioaccumulation and transfer factors less than 1.00. *A. spinosus* accumulated 78% of Cd (5.24) and 42% of Pb (51.32) in its root more than other weeds. The study concluded that *Amaranthus spinosus* displayed the highest phytoremediation potential than other weeds. However, *Euphorbia heterophylla*, *Sida acuta* and *Synedrella nodiflora* could serve as phytostabilizers in Cd and Pb contaminated soils.

Keywords: Phytoremediation, weeds, augmentations, bioaccumulation and phytostabilizers.

* Omotola Dada, Department of Ecology and Environmental Studies, Ikeji-Arakeji, Nigeria
abolaji_dada@yahoo.co.uk

67B

Freeman, John

Selenium phytoremdiation – bioremediation system: A long term sustainable approach to manage threatened agricultural areas

John Freeman*, CSU Fresno / NASA-Ames; Gary Banuelos, USDA-ARS; Krassimira Hristova; Marquette, Radomir Schmidt, UC Davis

Our integrated on-farm drainage management system (IFDM) uses salt tolerant crops, selenium hyperaccumulator plants, and halophytic plants to manage excess salt /selenium in agricultural drainage impacted soils / irrigation drainage water. The phytoremediation of selenate laden soils is especially efficient using the Selenium hyperaccumulator *Stanleya pinnata.* On a larger field scale we achieved the hyperaccumulation and removal of substantial Se in the above ground shoots of high biomass producing salt and boron tolerant *S.pinnata* hybrids*.* Furthermore, the excess Se in runoff waters from the IFDM is directed into an integrated engineered aquatic ecosystem specifically designed to bioremediate selenate. This engineered aquatic ecosystem also produces brine shrimp enriched in organic-Se, omega-3 and omega-6 fatty acids for use in value added nutraceutical food supplements. By analyzing the internal Se concentrations of the various food web organisms present in the engineered aquatic ecosystem we show that selenate was successfully bioremediated by micro-algal metabolism into organic-Se (seleno-amino acids and gaseous volatile-Se). Selenium is also removed by using nets to harvest the brine shrimp that had accumulated substantial amounts of organic-Se after eating aquatic microorganisms. Thriving in this pond system, brine shrimp(*Artemia franciscana* Kellogg) and brine fly (*Ephydridae* sp.), also have ecological relevance as important food sources for large populations of waterfowl, breeding and migratory shore birds. Together with the salt and boron tolerant crops, selenium hyperaccumulator plants, and halophytes this phytoremediation – bioremediation IFDM system represents a long term sustainable approach to manage and potentially rehabilitate currently threatened agricultural areas.

Keywords: Selenium hyperaccumulator-plants, engineered aquatic-ecosystem, IFDM

* John Freeman, NASA-Ames Research Center, Moffett Field, Mountain View CA
john.l.freeman@nasa.gov

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Eallonardo Jr., Anthony S.

Evapotranspiration from a unique wetland restoration site

Anthony S. Eallonardo Jr.*, O'Brien & Gere, Eco-Sciences; Donald J. Leopold, SUNY ESF, Department of Environmental and Forest Biology

The Solvay wastebeds is an urban complex of uncapped settling basins composed of Solvay waste--a sterile, inorganic, silty material composed of calcium carbonate, calcium sulfate, and magnesium hydroxide. While much of the Solvay wastebeds has revegetated with volunteer vegetation, one area—two hectares in size—was not vegetated approximately 30 years after cessation of deposition and was the targeted for restoration. The hypothesis governing this project was that the unique physiochemical environment provided by the Solvay waste (saline, alkaline, periodically waterlogged, infertile) was analogous to that of inland salt marsh and marl fen—globally imperiled plant communities. We predicted that restoring the site with species from these communities would be inexpensive and effective because these species are adapted to such conditions therefore do not require significant amelioration to support robust plant growth. In addition to the goal to restore these, and other, plant communities, another goal was to enhance site evapotranspiration as a sustainable means to reduce leachate production in lieu of building a traditional landfill cap. While restoration measures were initiated in 2008, evapotranspiration monitoring using the eddy covariance approach was initiated in spring 2011. This presentation will focus on evapotranspiration data and monthly crop coefficients from 2011 and 2012.

Keywords: crop coefficient, eddy covariance, inland salt marsh, marl fen

* Anthony S. Eallonardo Jr., 333 West Washington St., Syracuse, NY tony.eallonardo@obg.com

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Gurska, Jola

Phytoremediation of Petroleum Hydrocarbons in Soil: the Use of Amendments to Accelerate Degradation

Jola Gurska*, Stantec Consulting Ltd; Robin Angell, Stantec Consulting Ltd.; Bruce Greenberg, University of Waterloo; Tereza Dan, Stantec Consulting Ltd.; Gladys Stephenson, Stantec Consulting Ltd.

Phytoremediation is a cost-effective and feasible remediation strategy for sites impacted with petroleum hydrocarbons (PHC). The presence of plants stimulates growth of PHC-degrading bacteria surrounding the root zone through the release of plant exudates such as amino acids and carbohydrates. However, degradation can be hampered as PHC become sequestered in soil over time. Nonetheless phytoremediation has been shown to be successful on sites with aged, weathered petroleum hydrocarbons. The degradation kinetics display a decrease over time and generally fit the first order decay kinetics. Our hypothesis was that if the bioavailability of sequestered PHC could be increased, then PHC degradation rates would also increase, accelerating the phytoremediation process.

Therefore amending soils with naturally produced biosurfactants (rhamnolipids) was expected to improve PHC bioavailability and thus the rates of remediation. Rhamnolipids are of low toxicity and are ultimately degraded by bacteria. Four distinct, highly weathered PHC-contaminated soils were collected from a former land farming site at an oil refinery, containing mostly high molecular weight PHC (Canadian Council of Ministers of the Environment fraction 3 [F3] and fraction 4 [F4]), with PHC concentrations ranging from approximately 5,000 ppm (F3 + F4) to 18,000 ppm (F3 + F4). Application of rhamnolipids at two concentrations was tested in bench scale greenhouse trials. To date, trial results have indicated that rhamnolipids accelerated remediation comparing to unamended soils at select PHC levels. Results will be discussed with considerations necessary when analyzing PHC levels with concurrent addition of organic amendments to impacted soils.

Keywords: soil, petroleum hydrocarbons, bioavailability, biosurfactants

* Jola Gurska, 70 Southgate Dr., Guelph, ON, Canada jola.gurska@stantec.com

70B

Bradfield, Scott

Enhanced efficiency of photosynthesis and water deficit from exposure to TiO_2 and SiO_2 nanoparticles respectively

Scott Bradfield* and Stephen Ebbs, Department of Plant Biology, Southern Illinois University Carbondale

With the rapidly increasing world population, there has been a demand for an increased food supply. However, with the growing population will come a limited availability of agricultural land and water resources. Nanotechnology may offer a means to solving this problem by potentially enhancing photosynthetic efficiency through the application of engineered nanoparticles (ENPs). Ongoing research is examining the effect of anatase-TiO2 nanoparticles on physiological processes in two plant species (corn and soybean). Prior research with spinach has shown that foliar application of anatase-TiO2 nanoparticles increase activity of Rubisco and Rubisco activase, as well as chlorophyll synthesis. However, the mechanisms by which the TiO2 ENPs enhance these aspects of photosynthesis are still not yet understood. This research will provide additional information regarding the responses of photosynthesis to foliar ENP application and consider also the subsequent effect seed quality and/or quantity. Additional efforts will examine whether silica dioxide nanoparticles influence the response of the two plant species (corn and wheat) to water deficit. Efforts will again investigate the physiological basis for the observed effects. Overall, this primary focus of this work is to examine positive effects of these two ENPs on plant growth, development, and tolerance to abiotic stress while also providing mechanistic information to describe the functional basis of that response.

Keywords: nanoparticles, titanium dioxide, silica dioxide, photosynthesis, water deficit

*Scott Bradfield, presenting author, 420 Life Science II, 1125 Lincoln Dr., Carbondale, IL, 62901-6509, Southern Illinois University, Carbondale, IL sbradfield@siu.edu

71B

Vanek, Tomas

Phytoremediation of agricultural waste waters in real scale.
Ideas, experiments and realization

Tomas Vanek*, IEB ASCR, Petr Soudek IEB ASCR, Tereza Hudcova Dekonta, Jiri Syrovatka Chramce Farm, Sarka Petrova IEB ASCR, and Radka Podlipna IEB ASCR

Agricultural production belongs in Europe to the substantial emitters of wastewaters. However, only little attention has been given to development of optimal technology for its treatment. The development of waste technologies is usually associated with utilization of waste materials, which enable production of substances with potential application as energy or nutrient sources., This is not the case of agriculural waste waters, which have not risen higher economic interests to deal with them, as they contain only low concentrations of pollutants, moreover being spread in the countryside. As small farmers, who want to solve these problems, are usually limited by the financial resources for such wastewater treatment, it is necessary to develop relatively simple system based on processes ongoing in the nature. Cleaning of these small diffuse resources of pollution in the country represents a highly relevant topic nowadays.
Bioremediation of wastewater in the Aquatic integrated recirculation system is based on a combination of various approaches, which deal with water chemistry, utilize abilities of artificially constructed wetlands and aquaculture.
The aim of this project is construction of an integrated biotechnology unit, based on phytotechnology principles, which would address the issue of farm waste stream cleaning and woud be able to replace the existing, mostly ineffective approaches to the treatment of agricultural waste waters, which do not involve checking of the quality of resulting waters discharged into the environment.
Main aims are:
a) operational sustainability,
b) reduction of the cost of fertilizers by recycling nutrients back into the farm
c) elimination of the negative effects of discharges on the environment by reducing nutrient and other contaminant loading into the surface water

* Tomas Vanek, Laboratory of Plant Biotechnologies, Institute of Experimental Botany AS CR, v.v.i. Rozvojová 263, 165 02 – Prague 6, Czech Republic, vanek@ueb.cas.cz

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Kissoon, La Toya

Potential uptake of cadmium by *Lemna minor* from cadmium-contaminated wetlands: a mass balance approach

La Toya Kissoon*, North Dakota State University; Nicholas Peterson, North Dakota State University; Donna Jacob, North Dakota State University; Marinus Otte, North Dakota State University

Aquatic plants provide a crucial link between the inorganic and abiotic environment, and influence water and sediment chemistry. *Lemna minor* is a free-floating aquatic plant and so receives nutrients directly from the surrounding water. This aquatic plant is an important food source for a variety of water birds, and is also consumed by muskrat, beaver, and fish. With increasing concentrations of metals in wetlands, aquatic plants such as *Lemna minor* can accumulate high amounts of metals which have the potential to be transferred to water birds. But because of this trait *Lemna minor* can also be used to remove large amounts of nutrients and contaminants from water. Previous studies have shown that *Lemnaminor* can accumulate high concentrations of various metals from waste water including Cd, Cu, Cr, Ni, and Pb. The growth rates and ease of harvest of *Lemna* spp. make it an ideal candidate for use in phytoremediation. Soil or sediment used in treatment or mitigated wetlands contribute to element concentrations of the overlaying water. We grew *Lemna minor* in pots of water and Cd-contaminated soil to investigate the potential for Cd to move from the soil through the water column and into plant tissues. Cadmium content of the water, soil, and plants were determined to calculate a mass balance. Preliminary results show that cadmium uptake was greater for *Lemna minor* grown in water with Cd-contaminated soil compared to non-contaminated soil.

Keywords: cadmium, *Lemna minor*, metals, wetlands

* La Toya Kissoon, PO Box 6050, NDSU Dept 2715, Fargo, ND latoya.kissoon@ndsu.edu

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Yrjälä, Kim

Starting rhizoremediation of creosote site in cold climate using hybrid poplar

Kim Yrjälä*,Populus group Oy and University of Helsinki; Pauli Siivonen,University of Helsinki; Pirjo Tuomi, Golder Associates; Shinjini Mukherjee, University of Helsinki

Creosotes, a complex mixture of PAHs and phenolic compounds, have commonly been used as wood preservatives for railroad ties/railway sleepers. In southeastern Finland, a 7 ha wood treatment facility for railroad ties was abandoned in the 1960's, and PAHs have spread to the groundwater. The environmental pre evaluation of the site showed elevated levels of PAHs comprising an area of ca. 1.7 ha. The soil is mainly fine sand and the dominating vegetation was small Scots pines together with some birches, aspens and willows. Ground vegetation is mainly lichens, and some hay species, indicating low nutrient and moisture levels of the soil. Chemical analysis revealed pollution gradients of PAHs. The polluted area will be phytoremediated using hybrid poplar which is the fastest growing tree species in Scandinavia. The inherent biodegradation potential was assessed by soil DNA analysis depicting structural and functional microbial diversity through fingerprinting of 16S rRNA and aromatic ring-cleavage genes. The soil biological activity was assessed by respiration and enzyme activity measurements. PAH analysis of water sampled from ground water wells was performed, and the location of the plume was determined. Characterization of microbial communities in the water will aid the development of groundwater remediation methods.

Keywords: soil respiration, FDA enzyme activity, T-RFLP, 16S rRNA, PAH

* Kim Yrjälä, Viikinkaari 6, c/o Cultivator I, 00790 Helsinki, Finland kim.yrjala@helsinki.fi

74B

Ma, Chuanxin

Physiological and Molecular Response of *Arabidopsis thaliana* to Nanoparticle Cerium and Indium Oxide Exposure

Chuanxin Ma*,University of Massachusetts; Sudesh Chhikara,University of Massachusetts; Baoshan Xing, University of Massachusetts ; Craig Musante, The Connecticut Agricultural Experiment Station; Jason C. White, The Connecticut Agricultural Experiment Station and Om Parkash Dhankher, University of Massachusetts

The effects of cerium oxide (CeO_2) and indium oxide (In_2O_3) nanoparticle (NPs) exposure on *Arabidopsis thaliana* were investigated. After inoculation in ½ strength MS medium amended with 0-2000 ppm CeO_2 and In_2O_3 NPs for 25 days, both physiological and molecular responses were evaluated. Exposure at 250 ppm CeO_2 NPs significantly increased plant biomass but at 500-2000 ppm, plant growth was decreased by up to 85% in a dose dependent fashion. At 1000 and 2000 ppm CeO_2 NPs, chlorophyll production was reduced by nearly 60% and 85%, respectively, and anthocyanin production was increased 3-5 fold. Malondialdehyde (MDA) production, a measure of lipid peroxidation, was unaffected by exposure to 250-500 ppm CeO_2 NPs, but at 1000 ppm, MDA formation was increased by 2.5-fold. Exposure to 25-2000 ppm In_2O_3 NPs had no effect on *Arabidopsis thaliana* biomass and only minor effects (15%) on root elongation. Total chlorophyll and MDA production were unaffected by In_2O_3 NPs exposure. Molecular response to NP exposure as measured by qPCR showed that both types of elements altered the expression of genes central to the stress response such as the sulfur assimilation and glutathione (GSH) metabolic pathway; a series of genes known to be significant in the detoxification of metal toxicity in plants. Interestingly, In_2O_3 NPs exposure resulted in a 3.8-4.6 fold increase in glutathione synthase (GS) transcript production whereas CeO_2 NPs yielded only a 2-fold increase. It seems likely that the significantly greater metabolic response upon In_2O_3 NPs exposure was directly related to the decreased phytotoxicity relative to CeO_2 treatment. The use of NP rare earth oxide elements has increased dramatically, yet knowledge on fate and toxicity has lagged behind. To our knowledge, this is the first report evaluating both physiological and molecular plant response from exposure to these important nanoparticles.

Keywords: Cerium oxide, Indium oxide, nanoparticles, phytotoxicity, gene regulation, *Arabidopsis thaliana*

* Chuanxin Ma, Stockbridge School of Agriculture, University of Massachusetts, 230 Stockbridge Rd, Amherst, MA 01003; chuanxin@psis.umass.edu

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Hoffman, Adam

Trichloroethylene Plume Detection using Hyperspectral Imaging

Adam Hoffman*, SUNY ESF; David Lewis, NRL-SSC; Amy Keith, NASA-MSFC; Justin McMullen, SUNY ESF Robert Hamilton, SUNY ESF; John Quattrocchi, SUNY ESF; Lee Newman, SUNY ESF

Phytoremediation is both an effective and efficient method of removing a variety of contaminants from the environment. However, post-installation monitoring can be costly, time consuming, and potentially have adverse effects on the plant system. Many contaminants, particularly chlorinated organic solvents such as Trichloroethylene (TCE), can be detected in leaf tissue using hyperspectral imaging. This non-invasive method could be miniaturized into a portable unit to be used in situ for real-time analysis of contaminant location and migration. Ideally, it could also provide valuable information to scientists considering establishment of new bioremediation sites; to have the ability to determine areas of highest contaminant aggregation. This novel, interdisciplinary approach contains three phases. Phase 1 was to repeat previously reported studies in which metabolites of TCE detected in leaf tissue in Poplar (*Populus trichocarpa* DN-34). In Phase 2, we will determine leaf level physiological changes that occur due to TCE exposure using SDS-PAGE. Lastly, in Phase 3, we will begin the development of a portable hyperspectral imager which will be designed specifically for TCE metabolite detection in plants.

Keywords: phytoremediation, trichloroethylene, remote sensing

* Adam Hoffman, Department of Environmental and Forest Biology, 416 Illick Hall, 1 Forestry Drive, Syracuse, NY 13210 adamhoffman@gmail.com

76B

Lum, A. Fontem

Phytotechnology in the tropics: the potential of goosegrass (*Eleusine indica*) to remediate soils contaminated by Chromium and Scandium

Ayeoffe Fontem Lum*, University of Buea, Emmanuel Suh, University of Buea

Phytotechnology is an environmentally friendly option for the remediation of polluted or contaminated soil and water using plants. In the tropics where climatic conditions are favorable for the growth of crops, this technology is very promising and cost effective. Heavy metals are serious inorganic pollutants in the natural environment and are primarily of concern due to their toxicity, persistence and bioaccumulation problem. The uptake of elements by plants depends on the species. Weeds are excellent for use in phytoremediation because of their fast rate of growth and high level of adaptability to environmental stresses, amongst other factors. The remediation potential of goosegrass (*Eleusine indica*), a dominant weed species, was evaluated in selected soils contaminated with heavy metals in an industrial zone in Cameroon. The species was identified, and the heavy metal content analyzed in roots and shoots. The pH of the soils ranged from 5.71 to 7.49. The mean concentration of these metals was 333.20 ± 365.061 ppm for Chromium and 37.40 ± 12.563 ppm for Scandium. The pearson's correlation coefficient matrix generated, indicated highly synergistic relations between Chromium and Scandium. The significant values obtained for the Translocation Factor, showed that goosegrass had adapted mechanisms for phytoextraction of both Chromium and Scandium from the soil.

Keywords: Phytotechnology, plants, goosegrass, heavy metals, chromium, scandium

* Ayeoffe Fontem Lum, Department of Agronomic and Applied Molecular Sciences, Faculty of Agriculture and Veterinary Medicine, University of Buea, lumfontem@yahoo.com

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Macek, Tomas

Aromatic pollutants-degrading bacteria in plant rhizosphere in contaminated environments

Tomas Macek*, Institute of Chemical Technology Prague; Ondrej Uhlik, Institute of Chemical Technology Prague ; Michal Strejcek, Institute of Chemical Technology Prague ; Lucie Musilova, Institute of Chemical Technology Prague ; Jiri Wald, Institute of Chemical Technology Prague ; Jakub Ridl, Czech Academy of Sciences ; Miluse Hroudova, Czech Academy of Sciences ; Cestmir Vlcek, Czech Academy of Sciences ; Martina Mackova, Institute of Chemical Technology Prague ; Katerina Demnerova, Institute of Chemical Technology Prague

Over the last few decades, significant quantities of potentially harmful chemicals have been released into the environment. The major contaminants are halogenated and nitrated alicyclic, aliphatic, aromatic and polyaromatic compounds. Many of them have shown to be toxic, mutagenic and carcinogenic or disrupting hormonal activity. Bioremediation uses naturally occurring organisms to degrade such compounds. Bacteria are natural born recyclers, converting organic compounds often to carbon dioxide and water. Given their diversity, versatility and rapid evolution, these are the best candidates to funnel xenobiotic compounds into natural biogeochemical cycles. Effective bioremediation of contaminated sites is often held back because environmental conditions are not optimal for the metabolic activity of degradative microflora. Therefore, our goal is to understand the linkage between various biotic and abiotic factors, vegetation, microbial diversity, metabolic activity and their consequences for more effective degradation. Our projects extend the long lasting research focused on phytoremediation studies with particular stress on the role of plants and their abilities to transform xenobiotics. The application of stable isotope probing and metagenomic approaches allows us to obtain more accurate information activity within the particular environment of plant rhizosphere under different conditions. These include fertilization, presence of various plant species, plant secondary metabolites, allochtonous microbes, etc. Overall, our results show that stable isotope probing combined with ultra-deep sequencing is a helpful tool to study biodegradation processes involving as-yet uncultured and unclassified bacteria and evaluate the effect of different plants.

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Keywords: rhizoremediation, phytoremediation, aromatic pollutants, metagenomics

* Tomas Macek, ICT Prague, Technicka 3, Prague 6, 16628 Czech Republic macekt@vscht.cz

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Alicea, Anna

Phytotoxicity and Bioavailability of Silver Nanoparticles to Hydroponic Hybrid Poplar and Willow Cuttings

Anna Alicea*, NCSU, Department of Forestry and Environmental Resources; Karen Bradham, USEPA ORD, Elizabeth Guthrie Nichols, NCSU, Department of Forestry and Environmental Resources

AgNPs (silver nanoparticles) are currently used in several industries and are also frequent constituents in common household products. Due to their prevalence, AgNPs have the capacity to enter all environmental compartments and bioaccumulate in humans. In this study, the phytotoxicity and bioaccumulation of bulk Ag (silver), AgNPs, and PVP-AgNPs (polyvinylpyrrolidone silver nanoparticles) to Populus deltoides x Populus nigra- OP367 and Salix nigra tree cuttings was examined in hydroponic solutions. Biomass, NRT (normalized relative transpiration), and absolute transpiration were all negatively impacted after exposure to bulk Ag in both willow and poplars and PVP-AgNPs in poplars. Phytotoxicity was not observed after exposure to AgNPs in willow and poplars. EC50 (Effective concentrations at 50%) were calculated using wilt as a response. AgNPs were found to be most toxic in poplar cuttings (1.95 mg/L EC50) followed by bulk Ag in both willow and poplars (9.72 mg/L EC50). The distribution of Ag in tree tissues was also examined. The roots were the primary sites for Ag bioaccumulation in poplar and willow cuttings and were statistically different from bioaccumulation in leaves ($p = 0.04$) and shoots ($p = 0.03$). The bioaccumulation of bulk Ag by cuttings was also greater than AgNPs and PVP-AgNPs, suggesting that dissolution of Ag ions governs uptake. Significant differences in bioaccumulation were not observed between tree species ($p = 0.23$). However, willows proved to be more tolerant to Ag uptake, illustrating their potential use in the phytoremediation of Ag in soil.

Keywords: silver nanoparticles, phytotoxicity, NRT, absolute transpiration

* Anna Alicea, 109 TW Alexander Drive, Mail Code D205-05, Durham, NC ambarnes@ncsu.edu

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Shifflett, Shawn Dayson

Meeting Woody Biomass Demands in North Carolina

Shawn Dayson Shifflett*, North Carolina State University; Dennis Hazel, North Carolina State University; Elizabeth Guthrie Nichols, North Carolina State University

The woody biomass/biofuel industry in North Carolina (U.S.A.) continues to grow as does concern for long-term, sustainable woody biomass production for bioenergy and traditional wood products. In North Carolina, there is little information about which hardwood tree species are best for biomass production under various management conditions. Woody biomass production on marginal lands is one approach to balance future competing needs for wood products and bioenergy. Producing biomass on marginal lands provides the dual opportunity to minimize environmental waste products while meeting wood production goals. This presentation will report on survival and growth of forty-two *Populus spp.* clones, *Eucalyptusbenthamii*, and seven tree species native to North Carolina at two municipal wastewater application sites for 2011 and 2012. *Populus* clones grew best at both sites and maintained moderate survivorship. Native green ash and bald cypress showed lesser growth but higher percent survivorship at both sites. Groundwater concentrations of NO_3+NO_2 and N-NH_4 remained below regulatory requirements throughout the study with one exceedance in February 2012 at one site. *Populus*s clones are strong candidates for woody biomass production, particularly short rotation production of 3-10 years. Green ash and bald cypress are candidates for rotations of 15-20 years for both bioenergy and wood products production. Establishment trials are expanding to former agricultural lands to evaluate productivity yields from site preparation such as discing, ripping, and bedding. New studies at the two municipal wastewater sites will evaluate the effect of coppicing on *Populus* biomass yields and wood quality.

Keywords: woody biomass, *Populus,* species trial, municipal wastewater, bioenergy

* Shawn Dayson Shifflett, 2800 Faucette Blvd, Raleigh, NC 27607 shawndayson@gmail.com

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Afegbua, Seniyat

Effect of plant growth promoting bacteria, *Pseudomanas putida* UW4 on plant biomass yield and phytoremediation of mixed PAH-contaminated soil

Seniyat L Afegbua*, Lesley Batty and Joanna Renshaw, University of Birmingham, United Kingdom.

PGPB are extensively used to improve plant growth, yields and plant stress tolerance in agriculture but their application to phytoremediation of contaminated land is a relatively new remediation technology. Few studies have reported the effect of PGPB on plant tolerance and growth in the presence of organic toxicants and metals. This study was designed to assess the effect of PGPB; *Pseudomanas putida* UW4 on plant growth, biomass yield and phytoremediation efficiency in two different treatments; phenanthrene, fluoranthene and benzo[*a*]pyrene (PAH) and phenanthrene, fluoranthene and benzo[*a*]pyrene, and heavy metal; lead (PAH+HM). Alfalfa, tall fescue, ryegrass and mixed plant (ryegrass and tall fescue) were used for this study. Results showed differences inplant growth and biomass yields in both PAH (shoot; 8-20% and root; 11- 65%) and PAH+HM (shoot; 11-65% and root; -4 - 101%) treatments with PGPB although the yields were not significantly different. PGPB addition had stimulatory effect and in a few cases had no effect or an inhibitory effect on PAH dissipation. An increase in PAH dissipation from treatments with PGPB addition was observed especially for fluoranthene in some treatments. PAH dissipation was significantly different only for phenanthrene, fluoranthene and benzo[*a*]pyrene dissipations of the Alfalfa-PAH treatment and for phenanthrene and fluoranthene of the PAH+HM treatment. Other treatments had comparable PAH dissipations despite PGPB addition. Successful colonisation and survival of PGPB, plant type, plant-microbe interaction amongst other factors are important in improving plant biomass for an enhanced phytoremediation. PGPB addition may improve biomass yield without necessarily enhancing phytoremediation.

Keywords: plant growth, endophytic bacteria

*Seniyat L Afegbua, University of Birmingham, seniyat.larai@googlemail.com

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Desjardins, Dominic

Distribution patterns of ruderal vegetation and pollution at a former decantation basin

Dominic Desjardins*, Werther Guidi, IRBV, Frédéric Pitre, IRBV, Alexandre NAud, IRBV, Michel Labrecque, IRBV

Industrial pollution is a major and widely extended concern. Industrial activities often leave behind abandoned sites which then are open to natural revegetation, a process that will reflect in its pattern site's characteristics, including spatial pollutant distribution. The soil of a former decantation basin in Varennes (southern Québec) was systematically sampled and described in terms of spontaneous plant abundance and diversity as well as concentration of PAHs (polycyclic aromatic hydrocarbons), PHs (petroleum hydrocarbons C10-C50), various trace metals. Up to 61% of spontaneous plant distribution was explained by pollution distribution on the study site, when controlling for effect of pH, organic matter and cation exchange capacity. These findings provide important insights for design of site-specific and within-site remediation or rehabilitation. They also suggest using local and a greater diversity of plant species, which may have many associated benefits. The resulting design can be a more cost effective and environmentally sustainable alternative to traditional phytoremediation approaches.

Keywords: pollution, spontaneous vegetation, distribution patterns, partial redundancy analysis, site-specific, phytoremediation

* Dominic Desjardins, IRBV, 4101 Sherbrooke East, Montreal, Québec, Canada, dominic.desjardins.1@umontreal.ca

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Ransom, Beynan

Performance evaluation of a hybrid poplar phytoremediation barrier: Multiple lines of evidence at a Western New York site restoration

Beynan Ransom*, SUNY University at Buffalo; Jingqi Sui, SUNY University at Buffalo; Colleen Bronner, SUNY University at Buffalo; Alan Rabideau, SUNY University at Buffalo

This poster presentation provides an overview of two years of ongoing research into the effectiveness of a phytoremediation system installed at the former gravel pit in Machias, New York. Following the removal of waste drums containing trichloroethene (TCE) and subsequent groundwater treatment via air-sparging in 1994, aqueous TCE concentrations unexpectedly "rebounded" in 2007. Currently, a low concentration TCE plume is present in the groundwater adjacent to tributaries that eventually discharge to the Great Lakes. In 2011, a phytoremediation barrier (phytobarrier) was installed to intercept the plume, consisting of approximately 600 hybrid poplar and willow trees. The performance of the phytobarrier is being investigated through a multi-year research project jointly conducted by the University at Buffalo *Ecosystem Restoration through Interdisciplinary Exchange* (ERIE) program, in collaboration with the site owner Motorola Solutions Inc., the consulting firms KPRG and Associates Inc. and Ecolotree Inc., and the Wildlife Habitat Council. As part of this program, a "multiple lines of evidence" study is ongoing to address the impact of the phytobarrier on site hydrology based on measurements that include stream discharge, groundwater/stream temperatures, water table elevations, groundwater TCE concentrations, and evapotranspiration estimates. Additional activities include a life-cycle assessment (LCA) of the phytobarrier and additional enhancement of habitat conditions to accelerate restoration of the site to a more natural condition.

Keywords: plume delineation, habitat enhancement, water balance, temperature survey

* Beynan Ransom, 204 Jarvis Hall, Buffalo, NY 14260 beynanra@buffalo.edu

83B

Almeida-Rodríguez, Adriana

The role of *Rhizophagus irregularis* in copper uptake and storage in willows: A hydraulic perspective

Adriana M. Almeida-Rodríguez*, University of Montreal ; Simon Joly, University of Montreal and Montreal Botanical Garden; and Michel Labrecque, University of Montreal and Montreal Botanical Garden

Willow shrubs are good candidates for phytoremediation of polluted sites due to their fast growth, high biomass production, wide geographical distribution, and easy propagation. For plants to maintain a steady cellular function while accumulating trace-metals, dynamic changes in their water status must occur. The key to water movement throw cell membranes is Aquaporin (AQP) activity. Symbiotic associations between arbuscular mycorrhizal fungi (AMF) and plants are also important in moderating water uptake, among other beneficial effects on plants. We investigated the effect of symbiotic associations between AMF on the uptake and storage of copper (Cu) and on hydraulic traits and *AQP* expression patterns in roots of *Salix purpurea* saplings. Rooted saplings that were either inoculated or not with *Glomus irregulare* were grown under three Cu treatments: control, low (66.7 ppm Cu) and mild concentrations of Cu (156.78 ppm Cu). We found that root hydraulic conductance (*Lp*) was reduced in plants exposed to Cu when compared to controls in non-inoculated plants. In contrast, inoculated plants showed a steady *Lp* within the different levels of Cu, suggesting that the symbiotic relationships might maintain root homeostasis during trace-metal stress. A phylogenetic analysis of 29 functional *Salix* AQPs was conducted and four *AQPs* were transcriptionally profiled in roots. *SpTIP2;2* (Tonoplast Intrinsic Protein) increases its expression patterns in non-inoculated roots when exposed to Cu and it is highly expressed in inoculated plants in all Cu treatments. We concluded that this AQP might be involved in homeostasis balance in *S. purpurea* during Cu accumulation.

* Presenting author

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Abdul-Ghany, O

Effects Of Some Soil Treated Pesticides On Growth Characteristics Of Faba Bean And Wheat Plants

Abdul-Ghany O. I*, University of Salahaddin-Erbil and Sarmamy and Shelan M. Khidir, University of Salahaddin-Erbil

The present study was conducted during December 1st, 2009 to October 1st 2010 to determine the effects of Treflan, Glyphosate, Ridomil and Cyrin C, on germination, vegetative growth characteristics, nodulation (in faba bean), and nutrient status as well as pesticide residues in Wheat (*Triticum aestivum* L.) and Faba bean (*Vicia faba*) plants. Results showed that Treflan caused significant decrease in number of nodules per plant, number of branches, plant height, shoot fresh and dry weight in bean plants, and significantly reduced plant contents of potassium, sodium, zinc, manganese and calcium of bean plants. Treflan also reduced the number of tillers per plant, plant height, shoot fresh and dry weight, root dry weight and plant contents of total nitrogen, phosphorus, potassium, sodium, iron, zinc and manganese in wheat plants significantly. Cyrin C reduced the plant contents of nitrogen and manganese in bean plants. Ridomil decreased number of branches per plant in bean, root dry weights of both beans and wheat plants, and reduced the plant contents of nitrogen, sodium and manganese in bean plants and increase phosphorus, and manganese contents of wheat plants significantly. Glyphosate caused significant decrease in number of tillers per plant, plant height, shoot fresh and dry weight in bean and wheat plants and increased the contents of N, P, Na and decrease Fe contents significantly in wheat plants. Treflan was reduced the wheat seed germination percentage significantly and delayed the germination to 15 days. Cyrin C caused reduction in wheat seed germination, but Ridomil and Glyphosate were increased wheat seed germination percentages. All pesticide treatments delayed bean seed germination. After three months of pesticide treatments, residues of Metalaxyl (Ridomil) and chlorpyrifos were detected in samples of bean and wheat plants.

Keywords: pesticides, growth inhabition

*Abdul-Ghany O. I, Department of Biology, College of Science, University of Salahaddin-Erbil, Iraq abdulghani_umerr@yahoo.com

85B

Mukherjee, Arnab

Comparative phyto-toxicological effects of bare and silane coupling agent coated ZnO NPs on green pea plants (*Pisum sativum* L.) grown in soil

Arnab Mukherjee*, UTEP;Susmita Bandyopadhyay, UTEP; Cyren Rico,UTEP; Lijuan Zhao, UTEP;Jose R. Peralta-Videa, UTEP; Jorge L. Gardea-Torresdey, UTEP

The widespread use of bare and surface modified ZnO nanoparticles (NPs) increases the potential risk to human health and the environment. The ecotoxicological effects of bare ZnO NPs have been widely investigated. However, to the best of authors' knowledge, no studies have been reported about how the surface modification can affect the overall phytotoxicity of ZnO NPs on green pea plant, one of the most produced legumes worldwide. The present research was aimed to investigate the phytotoxic effects of bare and KH550 (3-Aminopropyl-triethosysilane) coated ZnO NPs on green pea plants. Toxicological effects were compared in terms of plant growth, relative chlorophyll content (SPAD), bioaccumulation of zinc, ROS production in terms of H_2O_2 formation, and activity of two antioxidative enzymes (catalase and ascorbate peroxidase) in root, stem, and leaves. The results indicate that bare ZnO NP treatments significantly increased the root lengths compared to control ($p \leq 0.05$). Relative chlorophyll content was decreased in all the treatments. At 500 mg/kg treatment, H_2O_2 concentration was increased only in leaves. Catalase and APOX activity was down regulated in leaves. However, the coated ZnO NPs showed less/no toxic effects when compared to that of the bare one in terms of plant growth, relative chlorophyll content, and ROS production. This comparative toxicological study will help to understand how surface modification can affect the NP-plant interactions.

Keywords: Nanoparticle, phytotoxicity, bare and coated ZnO NPs, ROS, antioxidative enzymes.

* Arnab Mukherjee, Department of Chemistry, University of Texas at El Paso, 500 W. University Ave, El Paso, TX-79968. akmukherjee@miners.utep.edu

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Majumdar, Sanghamitra

Translocation of cerium oxide nanoparticles in kidney bean plants and their effects on plant metabolism and seed nutrition quality

Sanghamitra Majumdar*, The University of Texas at El Paso; Jèsica Trujillo-Reyes, The University of Texas at El Paso; Jose R. Peralta-Videa, The University of Texas at El Paso; Jorge L. Gardea-Torresdey, The University of Texas at El Paso

In the last decade, there have been many toxicity assessment studies of several nanoparticles on plants. Previous reports have shown differential response of various edible plants to different metal-oxide nanoparticles. In spite of the overwhelming studies on nanotoxicity, there is scarce information on the effects of nanoparticles on the metabolic activities of the plants and the nutritional quality of their next generation fruits. Kidney bean (*Phaseolus vulgaris*) is an important source of proteins and essential nutrients worldwide. In the present study, kidney beans were planted in two types of soils, varying in the organic matter content and contaminated with cerium-oxide nanoparticles ($n$$CeO_2$; 0 to 500 mg/Kg). After 45 days of exposure, the plant leaves were analyzed for chlorophyll content, net photosynthesis and stomatal conductance to determine the effects of $n$$CeO_2$ on the process of photosynthesis. Also, quadruplicate samples of plant tissues are being analyzed for antioxidant enzymes, flavonoid content, chlorophyll, and antioxidant enzymes. ICP-OES will be used to determine cerium and micro/macro nutrient concentrations in different tissues including the fruits. The nutrient analysis of the next generation seeds of the nanoparticle exposed plants will also be performed using biochemical assays and molecular biology techniques.

Keywords: plant nanoparticle interactions

*Sanghamitra Majumdar, [1]Department of Chemistry, The University of Texas at El Paso, 500 West University Ave., El Paso, TX 79968

87B

Kaveh, Rashid

Transcriptional response of *Arabidopsis thaliana* exposed to the antiviral drugs Oseltamivir and Zanamivir

Rashid Kaveh*, Temple University; Benoit Van Aken, Temple University

The neuraminidase antiviral drugs, Oseltamivir and Zanamivir, are major medications currently used for the treatment of influenza. These drugs have been detected in municipal wastewater and they are likely to contaminate agricultural plants through irrigation with reclamation water and/or land application of biosolids. However, little is known about the effects of antiviral drugs on plants at molecular level. In this study, *Arabidopsis thaliana* plants were exposed to antiviral drugs, Oseltamivir and Zanamivir, and gene expression levels were analyzed using Affymetrix whole genome expression microarrays. Exposure to Oseltamivir (50 mg L^{-1}) for 21 days resulted in statistically significant up-regulation (fold change > 2.0) of 16 genes and down-regulation (fold change < 0.5) of 30 genes by reference to non-exposed plants. Exposure to Zanamivir (50 mg L^{-1}) for 21 days resulted in statistically significant up-regulation of 41 genes and down-regulation of 162 genes by reference to non-exposed plants. Many genes differentially expressed upon exposure to Oseltamivir and Zanamivir were involved in plant response to oxidative stresses, including superoxide dismutases, cytochrome P-450-dependent oxidases, and peroxidases. Although distinct gene expression patterns developed upon plant exposure to Oseltamivir and Zanamivir, a significant overlap of differentially expressed genes was observed between the two treatments (2 up-regulated and 15 down-regulated genes were detected in both Oseltamivir- and Zanamivir-exposed plants). These results suggest that whole genome expression analysis may be useful for detection of the chronic toxicity of emerging contaminants on plants, even when the short-term exposure does not result in observable physiological effects.

Keywords: antiviral drugs, Oseltamivir, Zanamivir, *Arabidopsis thaliana*, gene expression, microarray

* Rashid Kaveh, Department of Civil and Environmental Engineering, Temple University, 1947 N. 12th Street, Philadelphia, PA, bvanaken@temple.edu

88B

Yasin, Muhammad

Microbial-Enhanced Levels of Selenium and Essential Micronutrients in Wheat (*Triticum aestivum* L) - Applications in Biofortification and Phytoremediation

Muhammad Yasin*, Colorado State University, University of the Punjab, Quaid-e-Azam Campus; Elizabeth A. H. Pilon-Smits, Colorado State University; Muhammad Faisal, University of the Punjab

Selenium (Se) is an essential trace element for humans and other mammals. Most dietary Se is derived from crops. To develop a Se biofortification strategy for wheat, the effect of selenate fertilization and bacterial inoculation on Se uptake and plant growth was investigated.Selenium-tolerant bacterial strain YAM2 was isolated from industrially contaminated sediment and identified using 16S rRNA sequencing, showed 99% homology with *Bacillus pichinotyi*. YAM2 was tested for its capacity to enhance growth, Se accumulation, and acid phosphatase activity in wheat (*Triticum aestivum* L) growing in Se-fertilized soil. Wheat inoculation with YAM2 enhanced wheat growth. Se-treated inoculated plants showed significantly higher dry weight (35%), shoot length (16%) and spike length (11%) compared to un-inoculated Se-treated plants. In the absence of Se, inoculated plants also showed significantly higher dry weight (41%), shoot length (14%) and spike length (5%) compared to un-inoculated controls. Un-inoculated Se-treated plants showed a significantly higher dry weight (38%), shoot length (5%) and spike length (8%) compared to control plants without Se. In the presence of Se, bacterial inoculation significantly enhanced Se concentration in wheat kernels (167%) and stems (252%), as well as iron (Fe) levels in kernels (70%) and stems (147%), calcium (Ca) levels in stem (143%) and sulfur (S) levels in stem (8%) compared to uninoculated plants. Inoculated Se-treated plants showed a significant increase (40%) in acid phosphatase activity, which may have contributed to the enhanced growth.Inoculation with *Bacillus sp.* YAM2 is a promising biofortification strategy for wheat and potentially other crops. It may also enhance Se phytoremediation. Moreover, Se fertilization can effectively stimulate wheat productivity.

Keywords: Selenium, *Bacillus pichinotyi*, Wheat, Biofortification, Fe, Ca, S, ICP-AES

***** Muhammad Yasin, Department of Biology, Colorado State University, Fort Collins, Colorado 80523-1878, USA; yasin_mmg@yahoo.com

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Rafique, Uzaira

Phytoremediation of Polycyclic Aromatic Hydrocarbons on Fungal Species: A Green Sustainable Approach

Uzaira Rafique* and Sumreen Iqbal, Fatima Jinnah Women University,

PAHs are highly toxic environmental organic pollutants, liable to long-scale transport and subsequently adding up in the food chain. PAHs have received great concern due to their high carcinogenic potency and widespread environmental pervasiveness.

Earlier studies focused on biosorption and biodegradation of PAHs on bacteria rather than fungi. Fungal biomass provides economical sorption material due to its availability as industrial by-product or waste. The present study is an attempt to explore the remediation of PAHs using dead biomass of fungal species. *Aspergillus niger* and *Aspergillus flavus* sieved through 100 mesh (149µm) was applied in batch adsorption experiment for the removal of anthracene, phenanthrene, fluoranthene and pyrene. The data for the uptake of PAHs shows a general increase in adsorption till equilibrium at 24 hours is attained. The initial slow migration of PAHs to less accessible sites into the adsorbent is reported. Increase in induced PAHs decreases the percentage removal. However, *Aspergillus niger* is proven better adsorbent than *Aspergillus flavus* removing 76.63% pyrene, 74.59% fluoranthene, 74.05% anthracene and 73.58% phenanthrene. Removal capacity of fungal species decreased with increase in pH from acidic to alkaline. This trend is also demonstrated by other researchers using *Aspergillus niger*mycelia. The adsorbed concentration of each PAH was determined in terms of K_d, correlation studies, adsorption isotherms and adsorption kinetics. The fitting of experimental data was fitted to adsorption isotherms and adsorption kinetics showing good approximation for pseudo-second order (R^2> 0.99) and Langmuir (R^2> 0.9) model for adsorption of PAHs on fungal species.

Keywords: Phytoremediation, PAHs, batch experiment, beaver whacker, hot pepper poplar

***** Uzaira Rafique, Department of Environmental Sciences, Fatima Jinnah Women University, The Mall Rawalpindi, 46000, Pakistan uzairaiqbal@yahoo.com

90B

Will, Logan

Initial Genomic Survey of Poplar OP-367 and Brandywine tomato after inoculation with the plant endophyte *Enterobacter* sp. 638

Logan Will*, State University of New York, College of Environmental Science and Forestry (SUNY ESF); Adam Hoffman, SUNY ESF, Justin McMullen, SUNY ESF, Lee Newman, SUNY ESF

Enterobacter sp. 638 is a plant endophyte that has been shown to produce volatile compounds that act as plant growth-promoting hormones in poplar (*Populus deltoides* x *nigra*) OP-367. This mutually symbiotic relationship between the two organisms may potentially have positive implications for biomass production and phytoremediation efforts. As plant growth time is reduced, turnover rates for biomass feedstocks could also be reduced. The increased growth time could also be utilized to shorten long-term phytoremediation projects using poplar as the main remedial application. Similarly, *Enterobacter* sp. 638 has also been shown to increase crop productivity in tomato (*Solanum lycopersicum* ‘Brandywine’). However, little is known about what genes are affected in poplar and tomato after inoculation with the endophyte.Here, we report on initial genetic analysis of poplar and tomato after bacterial inoculation with the plant endophyte *Enterobacter* sp. 638.

Keywords: endophyte, poplar, tomato, biomass, phytoremediation, crop productivity

* Logan Will, 1 Forestry Drive, 246 Illick Hall, Syracuse, NY lrwill@syr.edu

91B

Parisa Akbari

FYM and AMF alleviate the phytotoxicity of soil lead: influence on growth of Chamomile (*Matticaria ricutatia L*)

Parisa Akbari*, Tarbiat Modares University; Amir Ghalavand, Tarbiat Modares University; Ebrahim Mohamadi goltape, Tarbiat Modares University and Om Parkash Dhankher, University of Massachusetts

The experiment was conducted on pots under greenhouse conditions and consisted of arandomized complete block design with factorial arrangement with 24 treatments and 3 replications to improve the metal tolerance and growth response of the Chamomile plants on soil; having different concentrations of lead (0, 100, 500, 1000 ppm). The soil was amended with farmyard manure (FYM) [control and (10 w/w)] and two different isolates of arbuscular mycorrhizal fungi (AMF) (*Glomus mosseae* and *Glomus intraradices*) and non-innoculated controls. The results of the study showed that lead stress decreased plant height,number of branches per plant, number of flowers per plant, Flower diameter (mm), dry flower per plant, root length (cm), root and shoot biomass. The content of epigenin-7-glucoside, oil and chlorophyll were affected by increase metal concentration in soil. Also the increase in the lead levels in the soil induced a significant decrease in both *G. mosseae* and *G. intraradices* percentage of colonisation. However in general, the application of both AMF resulted in a significant increase in plant growth under lead stress, especially when FYM was applied. Phyiological analysis results as well as phytochemical properties of this plant showed that despite decrease in agronomical traits, chamomile could be proposed as a lead stress resistant medicinal plant and metal tolerance was further improved by addition of FYM ands AMF.

Keywords: Chamomile, lead stress, arbuscular mycorrhizal fungi, farmyard manure

Parisa Akbari, Stockbridge School of Agriculture,University of Massachusetts, 230 Stockbridge Rd, Amherst, MA 01003; pakbari@psis.umass.edu

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Wang, Xiaomin

Altered nitrogen source impacts plant biomass and cell wall formation

Xiaomin Wang*, Syracuse University, Caitlin Phalen, Syracuse University, Heather Coleman, Syracuse University

Nitrogen fertilization has been shown to improve plant growth and biomass production in many plant species. More recently it has also been shown to impact cell chemical and structural properties including chemical composition and fiber length. Despite these findings, the mechanisms behind the interaction between nitrogen and cell wall formation remain unclear. There is little research addressing the role of environmental factors such as nitrogen availability on cell wall formation. The goal of this research is to investigate the impact of various nitrogen sources on xylogenesis and cell wall formation in two species of deciduous tree to determine sources of environmental variation seen across ecosystems. Understanding the impact of nitrogen on xylogenesis and cell wall formation will provide further insight into the apparent, but not well understood link between nitrogen availability and carbon allocation and partitioning in trees. This research focuses on two deciduous tree species, *Populus* and *Salix*. Both species hold potential as bioenergy feedstocks and this data will be useful in understanding how xylogenesis is controlled and how nitrogen impacts carbon allocation and partitioning in trees.

Keywords: Nitrogen, poplar, biomass, cell wall chemistry

*Xiaomin Wang, Department of Biology, Syracuse University

93B

Jaffe, Benjamin

Elemental Allelopathy in an Arsenic Hyperaccumulator, *Pteris vittata*.

Benjamin D. Jaffe*, Northern Arizona University

Pteris vittata is a fern noted for both its ability to hyperaccumulate arsenic, and its potential use in phytoremediation. While the efficacy of using arsenic hyperaccumulators for phytoremediation is well known, there is still considerable debate over how this trait confers an advantage for the plant. Most current work focuses on the protection from herbivory theory; another possible explanation is elemental allelopathy. Elemental allelopathy occurs when a plant increases the bioavailability of a particular element in the soil, and tolerates the increased levels better than competitors. To test for the presence and relative role of elemental allelopathy, I measured soil arsenic concentrations associated within and around the canopy of *Pteris vittata* at three field sites in Central Florida. I also measured the effect of both solution and soil arsenic mediums on total growth of a bioassay (*Oxalis stricta).* We found that arsenic was statistically higher underneath the canopy and the representative arsenic concentrations decreased total growth of the bioassay by over 50%. The competitive advantage elicited through elemental allelopathy, may play an important role in maintaining the hyperaccumulation trait in areas of low arsenic contractions. In regards to the practical application for phytoremediation, the role of elemental allelopathy in cycling arsenic may require modifications to current protocol to help maximize efficiency in contaminant extraction.

Keywords: arsenic hyperaccumulation

*Benjamin D. Jaffe, Northern Arizona University, Flagstaff, AZ

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Yanitch, Aymeric

The potential of willows for phytoremediation of arsenic polluted sites: physiological results and molecular perspectives.

Aymeric Yanitch*, University of Montreal; Frederic Pitre, University of Montrealand Montreal Botanical Garden; Simon Joly, University of Montrealand Montreal Botanical Gardenand, Michel Labrecque, University of Montrealand Montreal Botanical Garden

Arsenic (As) is one of the most hazardous elements in the environment coming both from geologic and anthropogenic activities such as mining or other industrial processes.
According to the US Environmental Protection Agency (EPA), As is classified as a group A human carcinogen and might cause serious health effects, including different types of cancer as well as cardiovascular, neurological, haematological, renal, and respiratory diseases.
The toxicity of As in plants is mainly mediated by the competition between arsenate (AsV) and phosphate in metabolic processes. In addition, As could disrupt enzymatic activities by the binding of arsenite (AsIII) to thiol groups present in proteins. Regardless of the negative effect of As in plants metabolism, several species have shown the capacity to survive or avoid the stress associated to As, and some of them are even able to extract, degrade, or immobilize As contaminants.
Despite of a continuously growing number of As contaminated sites and the public health risk associated with them, limited financial resources are available for environmental remediation. Moreover, the most commonly used remediation technologies are costly and highly disruptive for the environment. In this study, we propose the use of phytoremediation as as an economic and environmental-friendly alternative for As polluted sites. Our goals are to show the ability of different plant species to survive and accumulate As in their tissues from a physiological and transcriptomic perspective in order to determine which species could be the most efficient for detoxifying polluted sites in the province of Quebec (Canada).
Results from a four weeks hydroponic study with *Salix purpurea 'Fish Creek'* saplings showed that these shrubs are able to support up to 5 ppm As without showing any significant symptoms while taking up and accumulating As in its tissues. Physiological measurements, including photosynthesis, transpiration, and biomass production, were measured in plants exposed to 0, 5, 30 and 100 ppm of As. Molecular analyses (Next Generation Sequencing and qRT-PCR) are currently in process in order to identify changes in the transcriptome in response to As and compare specific transcripts levels accumulation in leaves, stems and roots. In addition, a field trial experiment is currently in progress and it will be used for validating these results.

Keywords: willow arsenic remediation

*Aymeric Yanitch, Biodiversity Center, 4101 Sherbrooke East, Montréal, Québec, Canada
aymeric.yanitch@umontreal.ca

Sun, Ruilian

Nutrient Removal and Antioxidant Response of Three Emergent Macrophytes to Concentration Changes of COD, Nitrogen and Phosphorus

Ruilian Sun*, Environment Research Institute, Shandong University; Jian Liu, Environment Research Institute, Shandong University

Three macrophytes species (*Zizania latifolia*Turcz.,*Iris pseudacorus* L. and *Typha latifolia* L.) were studied in constructed microcosm wetlands in order to compare the ability of hydrophytes in purifying simulated polluted river water and to analyze plant responses to oxidative stress induced by chemical oxygen demand (COD), nitrogen and phosphorus. The results showed that planted microcosms were more effective in removing COD, total nitrogen (TN) and total phosphorus (TP) than unplanted microcosms. Among the three hydrophytes, *Z. latifolia* was superior for TN removal, while *I. pseudacorus* units showed the highest TP removal efficiency. However, there was no significant difference between planted units in COD removal efficiencies. The plasticity of *I. pseudacorus* was the best exposed to sewage, which was associated with significantly decreased malondialdehyde (MDA) content, higher superoxide dismutase (SOD) and catalase (CAT) activities under the condition of low concentration of COD/N/P (80/15/2 mg L^{-1}, T1). However, treated with treatment T1, the MDA levels of *T. latifolia* and *Z. latifolia* were basically unaffected. In addition, treatment of polluted river water induced enhancement in proline level of three species. It can be concluded that the antioxidative defence system and free proline accumulation were activated but could not resist the oxidative stress in plants exposed to high concentrations of COD/N/P (≥160/30/4 mg L^{-1}).

Keywords: *Zizania latifolia*, *Iris pseudacorus*, *Typha latifolia*, nutrient removal, antioxidant enzyme

*Sun Ruilian, 27 Shandanan Road, Jinan, China. ruiliansun@sdu.edu.cn

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Agtuca, Beverly

Bioavailability and Genetic Toxicity of Gold Nanoparticles in Soils and Hydroponic Exposures with *Lycopersicon esculentum* (Tomato 'Brandywine')

Beverly Agtuca*, State University of New York College of Environmental Science and Forestry (SUNY ESF); Justin McMullen, SUNY ESF; Wenjun Cai, SUNY ESF; Catherine Murphy, University of Illinois; Jason White, The Connecticut Agricultural Experiment Station; Tara Sabo-Attwood, University of Florida; Lee Newman, SUNY ESF

Nanotechnology is known to be an important force of the future economy and remains an appealing investment for governments and industries worldwide. Using nanotechnology may lead to nanoparticles (NPs) entering the environment through deliberate applications and accidental releases. This creates public debates and regulatory concerns, as NPs possess unique chemical and physical properties that can impact living systems. Recent studies have been done in mammalian model systems, but there are fewer studies on the toxicity of NPs in food crops. It has been concluded that gold NPs (AuNPs) cause biotoxicity as they have the potential to be internalized in the exposed plants by crossing the cell wall and membranes and accumulating within the plant. One limitation in these studies is that almost all have used plants in hydroponic solutions, which facilitates uptake. There are two objectives of this study: to look at the real world bioavailability that occurs in soil-based systems and to determine how different time exposures impact the expression of stress response genes to AuNPs. The plant tissues, soils, and hydroponic solutions were acid digested and analyzed by the inductively coupled plasma mass spectrometry. RNA was extracted from the plant tissues and analyzed by Quantitative PCR. Overall, difference in soil characteristics does affect the plant's uptake; high loam soil limits uptake and reduces availability more than sandy soil, while agriculture soil allowed higher uptake of AuNPs. This highlights potential human exposure routes when crop plants are exposed to or treated with nanomaterials.

Keywords: gold nanoparticles, toxicity, bioavailability, soil, tomato

* Beverly Agtuca, 1 Forestry Drive., Syracuse, NY bjagtuca@syr.edu

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Wenjun Cai

Toxicity screening of inorganic nanoparticles to Agricultural Crops

Wenjun Cai*, SUNY College of Environmental Science and Forestry (SUNY ESF); Jason C. White, Connecticut Agricultural Experiment Station (CAES); Roberto De La Torre-Roche, CAES; Joseph Hawthorne, CAES; Chen Wang, Southern Illinois University Carbondale (SIU); Xingmao Ma, SIU; Yingqing Deng, University of Massachusetts-Amherst (UMass); Baoshan Xing, UMass; Lee A. Newman, SUNY ESF

The toxicity of nanoparticles has been widely investigated in recent years. However, most data are based on the interaction between a certain type of nanoparticle and a certain plant. To provide a complete toxicological profile of the NPs and different agricultural crops, we compared four nanoparticles (Ag, CeO2, CuO and ZnO) and their corresponding bulk and salt particles' impact on three crop species. The agricultural crops applied in our studies are tomato, spinach, and pea. The increased biomass and accumulated transpiration were recorded daily during the exposure. Screening result indicates that there is significant difference among nanoparticles (20-55nm), bulk particle (80-100mesh) and salts. In particular, 500mg/L salt shows high inhibition of plant growth. However, no significant difference was found comparing nanoparticle and corresponding bulk particles. After ten day's exposure, the concentration of nanoparticles and their relative bulk and salt particles in plant leaves, stem and root was determined by ICP (Inductivity coupled plasma spectroscopy). Our results show that in all plant species, significant amount of metal accumulate in the leaves, while high concentration of nanoparticles were detected in the roots. This indicates that the majority of the nanoparticles were located in and on the root rather then being of transported into the leaves. As all types of nanoparticles show consistent result in all plants, it suggests that the toxicity is size dependent, as well as type dependent.

Keywords: Nanoparticles, Toxicity, Agriculture crops,

* Wenjun Cai, SUNY College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY 13210, wcai02@syr.edu

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Noori, Azam

Rhizo-remediation of heavy crude oil-contaminated soil by application of atropical grass

S.M. Mehdi Dastgheib, RIPI; Somayeh Ghanbarpour, RIPI; Ebrahim Alaei, RIPI; Azam Noori*, State University of New York College of Environmental Science *

Soil contamination due to oil spills is a serious environmental problem especially in oil-producing countries such as Iran. Phytoremediation is regarded as an emerging environment-friendly technology for the clean-up of oil-contaminated sites. In this study, heavy crude oil-contaminated soil was treated by a tropical grass in an open pilot. Experiments were conducted in the presence and absence of the plant at different crude oil levels. Results showed that microbial population in the rhizosphere area was in the range of 105 –106 CFU/g which was 100 times higher than unplanted soil. Accordingly, biodegradation was also promoted by phyto-treatment to more than 50 percent, which was about 20 percent higher than control soil. Since the plant growth and biomass production was not affected by hydrocarbon contamination, it could be concluded that phytoremediation is a promising method to raise soil microbial activity and has a notable effect on the degradation of hydrocarbon compounds.

Keywords: Oil-contaminated soil, TPH, Tropical plant, Rhizoremediation

* Azam Noori, 416 Illick Hall, 1 Forestry Drive, Syracuse, NY g-antooran@esf.edu

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Noori, Azam

Mycorrhizal *Lycopersicon esculentum* exposure tosilver nanoparticles

Azam Noori*, State University of New York College of Environmental Science and Lee A Newman, State University of New York College of Environmental Science

Nanoparticles are widespread in terrestrial, aquatic and atmospheric systems and can have detrimental impacts on plants. *Lycopersicon sculentum*, or garden tomato, is grown extensively in the US. Because of the monoculture systems, fungal diseases are common and different forms of proposed fungicides includes silver nanoparticles. Soil microorganisms such as mycorrhizal fungi are known due to their role in improving plant tolerance against abiotic and biotic stresses and also for their roles in rhizodegradation and phytoaccumulation. In current research *Rhizophagus intraradices* spores were used to colonize *L. esculentum* roots. Mycorrhizal and non-mycorrhizal *L. sculentum* were exposed to 25, 50, 75 and 100 ppm of 2nm silver nanoparticles for 20 days. Toxicity of nanoparticles (NPs) to plants, and the impact of the mycorrhizal fungi on plant accumulation of the nanoparticles determined. Roots, stems and leaves length and weight as well as mycorrhizal colonization were measured under each treatment. Plants (roots, stems and leaves) and soil silver NPs were measured with ICP-OES. The result showed that 100 ppm of 2nm silver NPs is toxic for *L. esculentum*, while for other concentration of silver NPs there was no sign of toxicity. Silver NPs content increased significantly in Mycorrhizal and non-mycorrhizal plants by increasing NPs concentration. The highest amount of silver detected in roots and the lowest in leaves. Mycorrhizal roots took up less silver NPs under 75 ppm while plant levels were higher when the plants were exposed to 25 and 50 ppm silver NPs. This can be due to mycorrhizal role to protect plants under environmental stresses. Silver transport to leaves was higher for 75 ppm in non-mycorrhizal plants compare to mycorrhizal ones which clarifies mycorrhizal role. Changes in gene expression in mycorrhizal and non-mycorrhizal plants exposed to sliver NPs will examine by using Q-PCR analysis in next step.

Keywords: ICP-OES, *Lycopersicon sculentum,* Mycorrhizae, Silver nanoparticles

*Azam Noori, 416 Illick Hall, 1 Forestry Drive, Syracuse, NY g-antooran@esf.edu

100B

Maietta, Vic

Properties and Microbial Community Analysis of Soil from the Tahawus Mine Site

Vic Maietta*, State University of New York College of Environmental Science and Forestry (SUNY ESF); Cherissa Dukelow, SUNY ESF and Lee Newman, SUNY ESF

Metal from agriculture, leather tanning factories, electroplating companies, coal burning power plants, and mining and transit has contaminated many environments with metals that are toxic to plants, microorganisms, and people. As of May 2004, the United States has over 40,000 contaminated sites according to the EPA. Physical and chemical properties of soil i.e. pH, conductivity, redox potential, particle size, and metal and organic content affect the types and abundances of soil bacteria, molds, and actinomycetes present. This also impacts plant recruitment and survival. TheTahawus Mine Site, located outside Newcomb, New York, within the Adirondack region is our study site. This site was originally an iron mine, which then switched over to titanium extraction, and is now in a shutdown phase. Physical and chemical properties of the soil substrate at different locations within the mine site will be assessed and compared where both colonizing and introduced plants are surviving and where they are not. ICP MS will be used to assess the concentration of metals present in the soil. Physiochemical properties such as pH, conductivity, and water holding capacity will be analyzed. The types and numbers of bacteria, molds, and actinomycetes are being assessed and compared between sites. It is hypothesized that areas with a more diverse soil community will be more conducive to plant establishment and growth while less hospitable sites will show a different or less diverse soil community and exhibit low plant recruitment and survival. It is hoped that this comparison will better guide land management and soil amendments to facilitate plant establishment.

Keywords: plant restoration, metal contaminantion

*Vic Maietta, 416 Illick Hall, 1 Forestry Drive, Syracuse, NY vjmaietta@gmail.com

101B

McMullen, Justin

Trichloroethylene Degradation by Genetically Modified Tobacco (*Nicotiana tobaccum var. xanthi)*

Justin McMullen, State University of New York College of Environmental Science and Forestry (SUNY ESF)*; Robert Hamilton, SUNY ESF; Adam Hoffman, SUNY ESF; Jirawan Tirot, SUNY ESF; and Lee Newman, SUNY ESF.

Trichloroethylene (TCE) contamination is a major problem in groundwater systems throughout the world. Phytoremediation strategies have been used in the past with good results; however, there is little to know information about how the plants are able to degrade the TCE. Additionally, if these genes and enzymes were known, the effectiveness of this technology could be enhanced by use of genetically modified plants that contain genes known to enhance the degradation of TCE. The human cytochrome P450 2E1 gene, which is known to metabolize TCE, has 5 homologous genes identified in the *Arabidopsis thaliana* genome, one which was shown to greatly enhance the effect of TCE degradation (Strycharz *et al.* 2006). These genes have subsequently been transformed into tobacco (*Nicotiana xanthi*) using T-DNA insertional mutations. Here, we report on the ability of the genetically modified tobacco to metabolize TCE more efficiently.

Keywords: bioremediation, Trichloroethylene (TCE)

* Justin McMullen, 1 Forestry Dr., Syracuse, NY jcmcmull@syr.edu

102B

Whitaker, Joseph T.

Potential for Ornamental Plants for Food Processed Waste Water Treatment

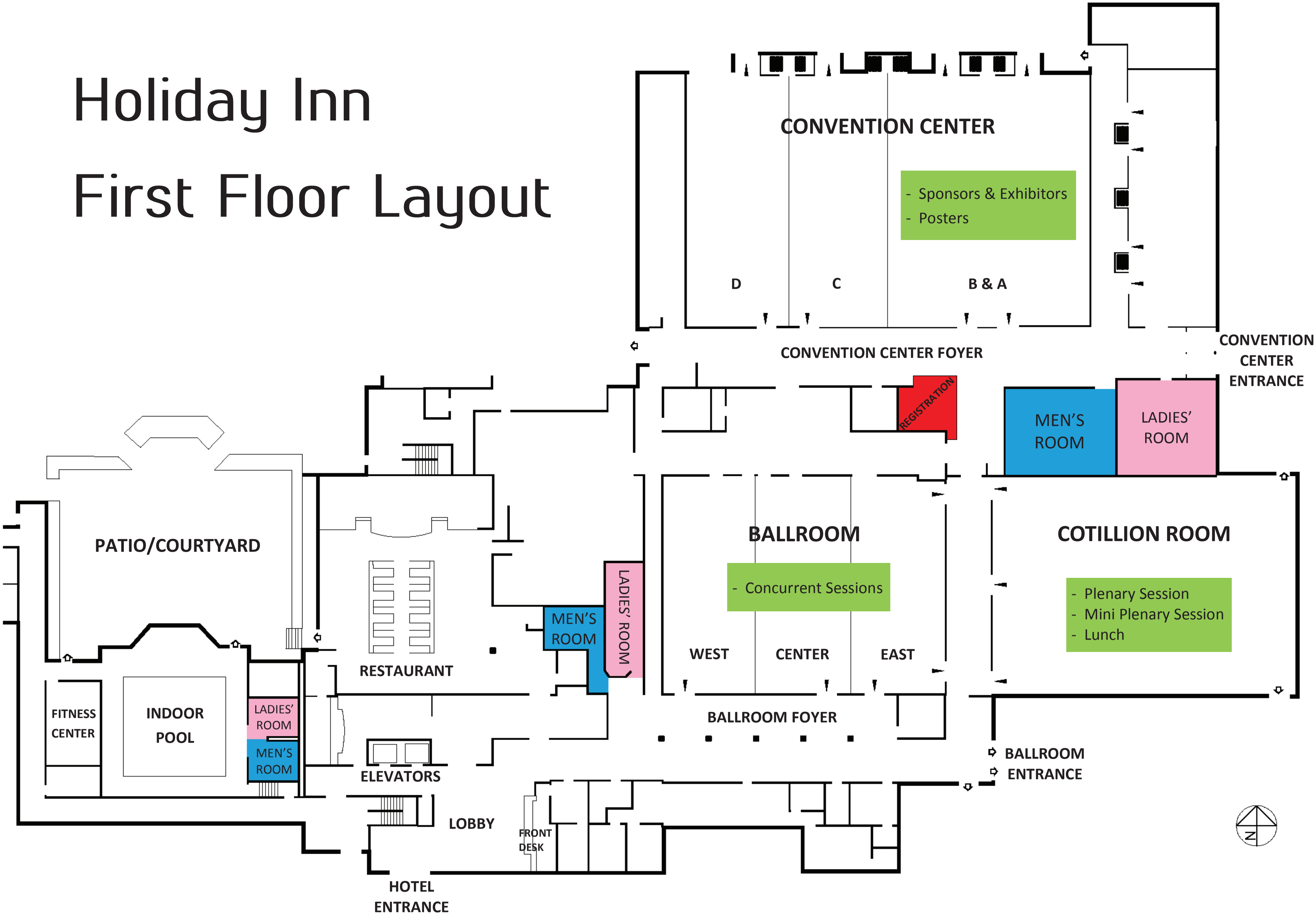
Joseph T. Whitaker*, State University of New York College of Environmental Science and Forestry; Scott Wolcott,Rochester Institute of Technology and Lee Newman, State University of New York College of Environmental Science and Forestry

The use of plants as a means of treating food processed waste water is a new and potentially beneficial type of phytoremediation. The objective of this study is to test how well selected ornamental plant species handle a high nitrogen and phosphorous waste water solution. In a best case scenario, the plants will not only survive in the waste water but will be able to reduce the high levels of nitrogen and phosphorous from the waste stream. The described portion of the experiment tested the survival potential of common ornamental plants, while other team members tested the survival potential of common agricultural plants. The common unit of measurement is the change in the biomass of the plants as the plants were grown in common Hoagland's solution or in the experimental waste water.

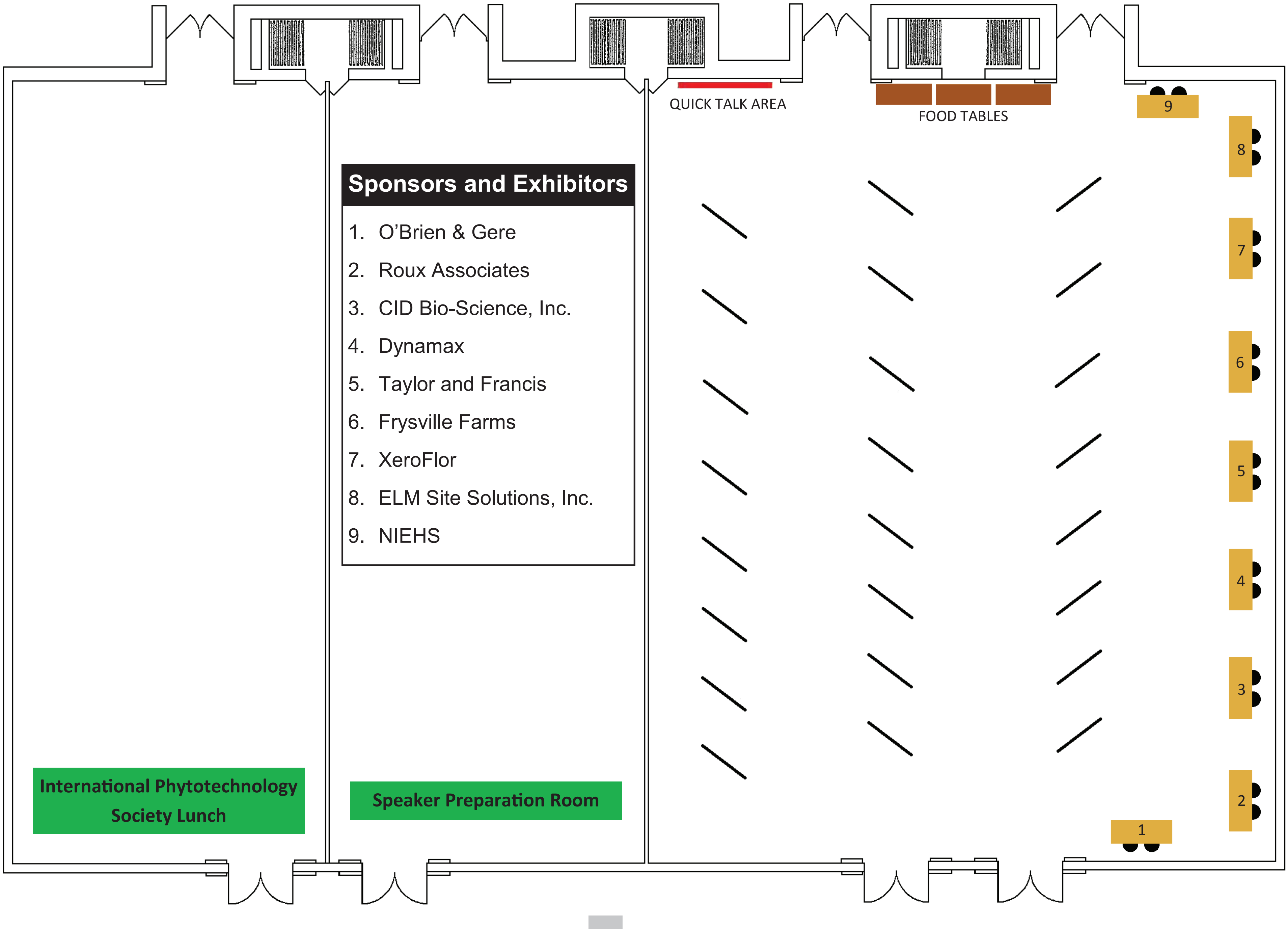
Keywords: green walls, waste water treatment

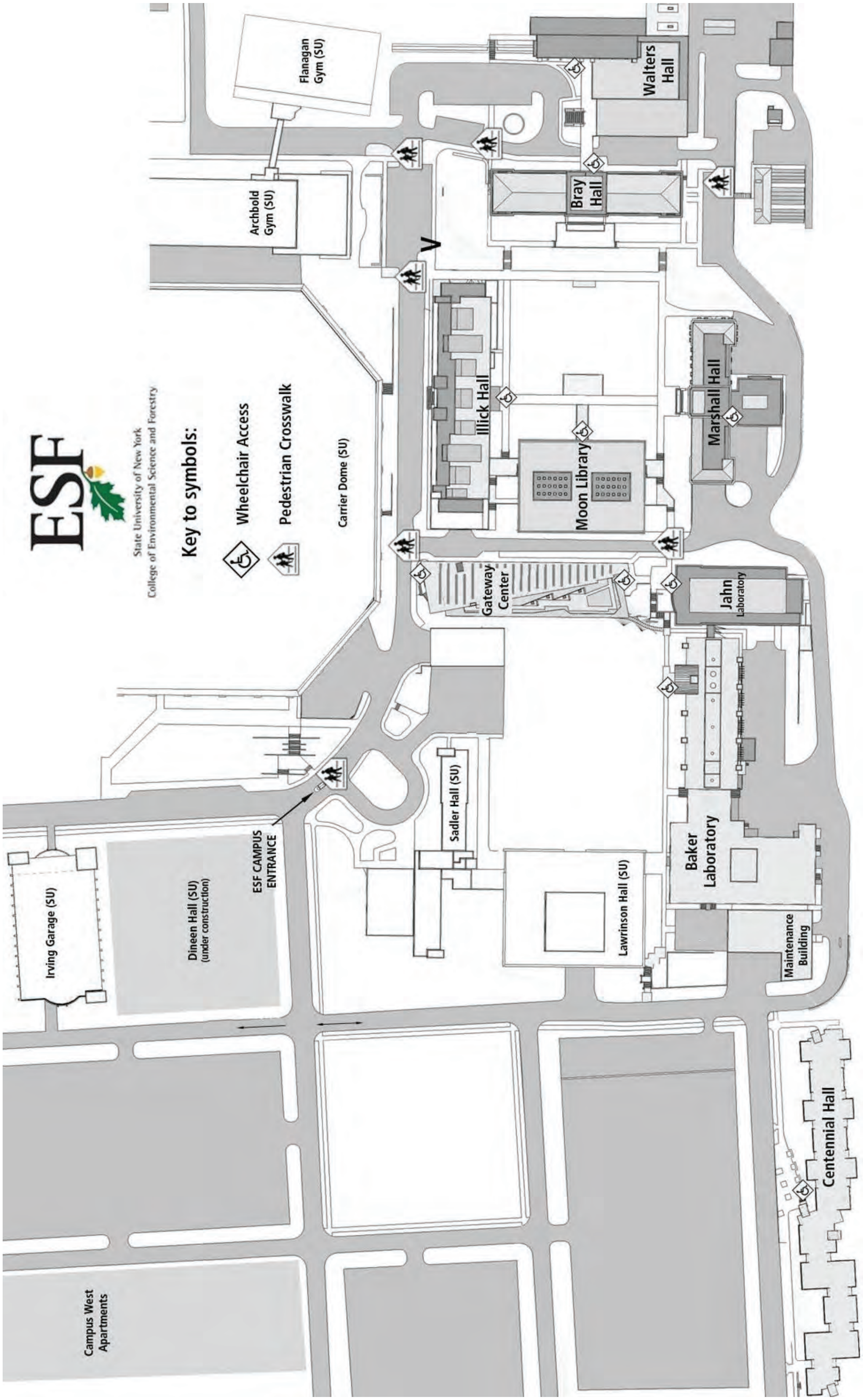
* Joseph T. Whitaker, 1 Forestry Dr., Syracuse, NY jtwhitak@syr.edu

Holiday Inn
First Floor Layout



Convention Center




ESF
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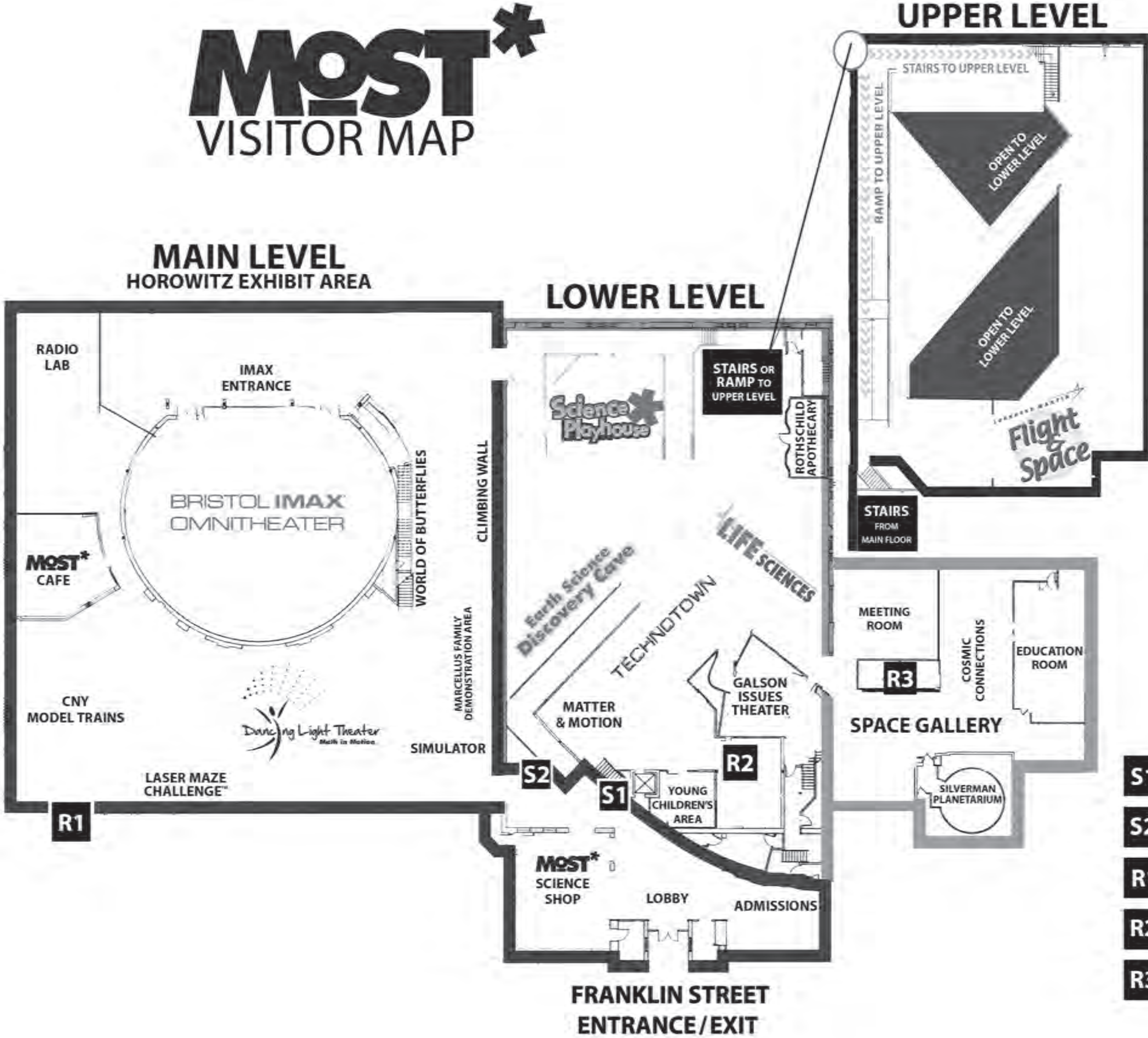
Key to symbols:
Wheelchair Access
Pedestrian Crosswalk
Carrier Dome (SU)
Flanagan Gym (SU)
Archbold Gym (SU)
Walters Hall
Bray Hall
Illick Hall
Moon Library
Marshall Hall
Gateway Center
Jahn Laboratory
Sadler Hall (SU)
Baker Laboratory
Lawrinson Hall (SU)
Maintenance Building
Irving Garage (SU)
Dineen Hall (SU)
(under construction)
ESF CAMPUS ENTRANCE
Centennial Hall
Campus West Apartments

MOST* VISITOR MAP



S1 STAIRS TO LOWER LEVEL

S2 STAIRS TO UPPER LEVEL

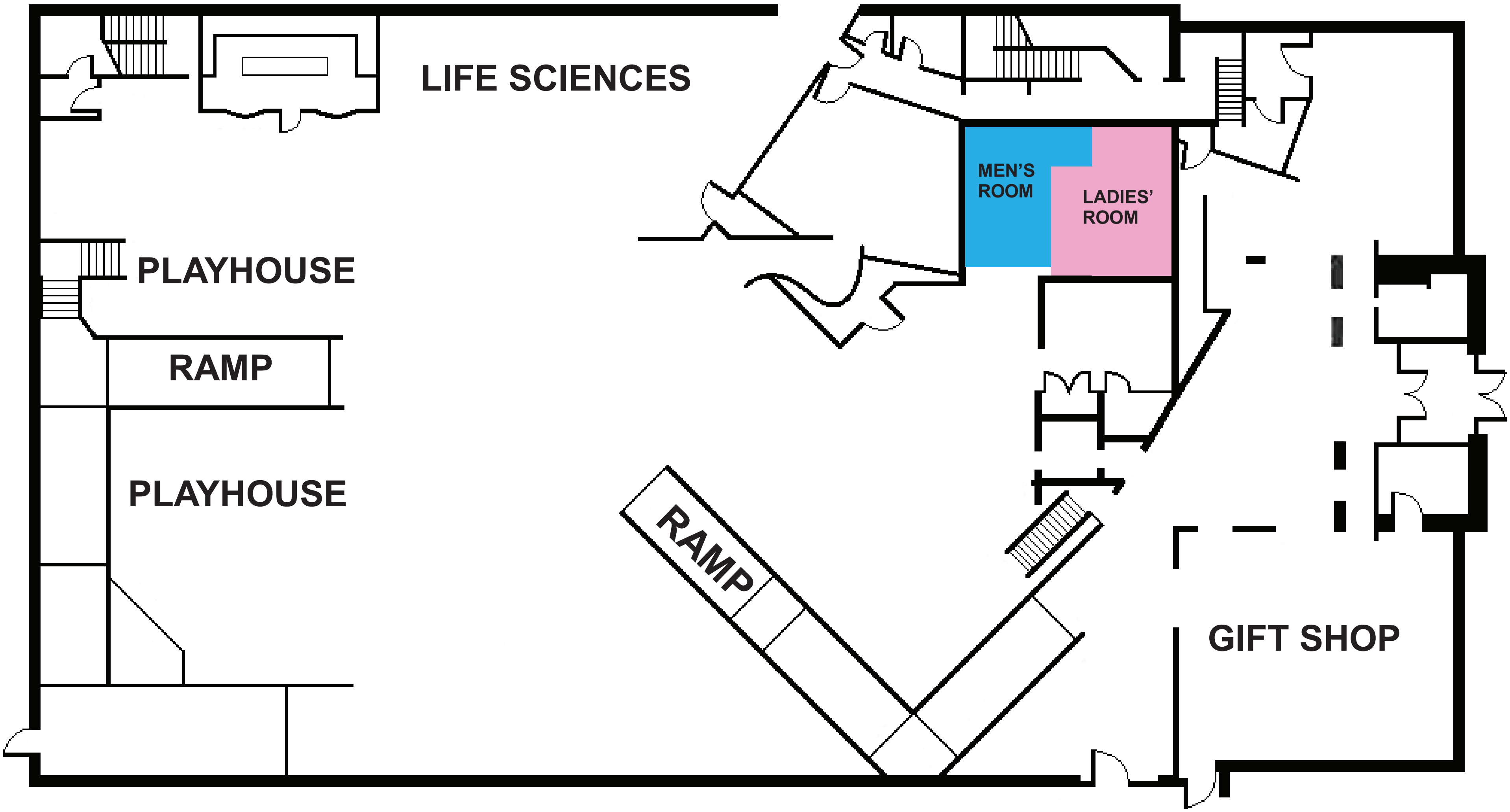
R1 RESTROOMS (Main Level)

R2 RESTROOMS (Lower Level)

R3 RESTROOMS (Lower Level)

Museum of Science and Technology

Lower Level



Museum of Science and Technology

Mezzanine Level