Phytotechnologies for Sustainable Development

12th International Conference
International Phytotechnology Society
2015 September 27-30 Hilton Garden Inn - Manhattan, KS

Hosted by the International Phytotechnology Society and Kansas State University

ABSTRACT BOOK

KANSAS STATE UNIVERSITY

Abstract Book

12th International Phytotechnologies Conference

Organized by:
International Phytotechnology Society

Hosted by:
Kansas State University

Editor:
Larry E. Erickson
ISBN 178-0-692-50825-1

Published by:
Kansas State University
Manhattan, KS

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12th International Conference | International Phytotechnology Society

PLATFORM ABSTRACTS

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Interplay between Brassinosteroids and Abascisic Acid Confers Cadmium Tolerance in Tomato

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Environmental pollution by heavy metals such as cadmium (Cd) is a serious problem worldwide. We observed that Cd-induced high concentration of reactive oxygen species caused oxidative damage to photosynthetic pigments, electrolyte leakage, lipid peroxidation and photoinhibition in tomato. Brassinosteroids (BRs) and abscisic acid (ABA) are two key plant hormones play critical role in plant stress responses. Previously, we demonstrated that BR could effectively ameliorate Cd stress in tomato; however, its interaction with ABA in Cd tolerance still remains elusive. Here, we used tomato genotypes Condine red (CR, wild-type) and its partially BR synthesis mutant dim, and Ailsa Craig (AC, wild-type) and its partially ABA-deficient mutant notabilis (not) to investigate the interactive effects of BR and ABA under Cd stress. Results show that a basal level of endogenous BR or ABA is essential for Cd tolerance. Either BR or ABA could confer Cd tolerance in wild-type plants which was associated with an increase in endogenous ABA level. Meanwhile, both dim and not plants were more sensitive to Cd stress; however, pre-treatment with ABA could improve Cd tolerance in both dim and not plants. Moreover, exogenous application of BR could improve Cd tolerance in dim plants, but not in not plants. Further investigation shows that ABA could complement BR-deficiency for Cd tolerance in dim plants. Inhibition of ABA biosynthesis by fluridone aggravated Cd phytoxicity; however, ABA supplementation but not BR, could reverse fluridone effect, which indicated that BR might function upstream of ABA to confer Cd tolerance in tomato.

Keywords: abscisic acid, brassinosteroids, cadmium, phytotoxicity, tomato

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3. Ahmad, Rafiq

Phytoremediation potential of Cannabis sativa and Parthenium hysterophorus:
Identification and characterization of GR and PLDα genes

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Soil pollution caused by heavy metals is one of the major problems throughout the world. To maintain a safe and healthy environment for human beings, there is a dire need to identify hyperaccumulator plants. This study was designed to explore the potential of Cannabis sativa and Parthenium hysterophorus to accumulate the toxic metals such as Pb, Cu, Zn, Co, Ni, and Cr in plant samples collected from industrial area of Rawalpindi, Pakistan. In addition, this research was conducted to identify two important heavy metals tolerant genes, glutathione-disulfide reductase (GSR) and phospholipase D-α (PLDα) in both plants. Our results showed that C. sativa plants collected from heavy metals contaminated site accumulated toxic metal concentrations significantly and in this pattern: Cu>Cd>Ni>Pb. In addition, the accumulation pattern of heavy metals in another plant P. hysterophorus leaves was: Cr>Cu>Pb>Ni. These results revealed that both these plants have the ability to accumulate heavy metals in their leaves and could be used in phytoremediation technology. Moreover, GR and PLDα genes were present in P. hysterophorus and C. sativa plants and could help plants to survive in heavy metal stress conditions. Bioinformatic analysis of GSR and PLDα genes exhibit 60-80% sequence identity to previously reported genes in other plant species. In conclusion, these results will help to improve our understanding about the phytoremediation potential of P. hysterophorus and C. sativa as well as in manipulating GSR and PLDα genes in breeding programs to produce transgenic heavy metals tolerant varieties.

Keywords: soil, phytoextraction, P. hysterophorus, C. sativa, genes, GSR, PLDα

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4. Ahmad, Syed Shakeel

Phytoremediation of heavy metals by Lemna gibba in a Kashmir Himalayan Ramsar site

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Heavy metals are important class of contaminants having hazardous impact on plants animals and humans. Wetland macrophytes offer important, cheap and natural alternatives for the removal of heavy metals from the contaminated environment. Diferent macrophytes vary in their potential to remove heavy metals from the surrounding environment. In this context the present study was carried out to investigate the metal removal capability of Lemna gibba growing densely in the Hokersar wetland of the Kashmir, an imporant Ramsar site of Kashmir Himalayas. The order of heavy metals in Lemna gibba was Fe > Al > Mn > Pb > Cu > Zn > Co > Cr > Ni > Cd. The EF of the different heavy metals in this species indicates that Fe is the most transferred metal into this species followed by Cd and Mn thus reducing the supply of Fe, Cd and Mn to marsh detrivores, avifauna, other bioaccumulators and surface waters. The highest BCF of Lemna gibba also corresponded to Fe metal which also supports the good phytoremediation ability of this species. Thus our results suggest that Lemna gibba is potent wetland macrophytes that can be used for removal of Fe from the contaminated soils.

Key words: Lemna gibba, Heavy metal, wetland, removal, avifauna.

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5. Ahmad, Waqar

Interaction of plant growth promoting rhizobacteria and gibberellic acid to facilitate the hyperaccumulation of selenium in Indian mustard (Brassica juncea L.)

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Selenium (Se) is ubiquitous in the environment. It is an essential nutrient for human and animals, however, it is also toxic at higher concentrations. The aim of this study was to check the effectiveness of Se tolerant plant growth promoting rhizobacteria (PGPR) alone as well as in combination with gibberellic acid (GA) for enhancing Se hyperaccumulation in Indian mustard. Bacteria were isolated from rhizosphere of Indian mustard. These rhizobacteria were tested for Se tolerance capability and efficient Se tolerant rhizobacteria were used as inoculum. Plants were irrigated with Hoagland solution contaminated with 20 µM sodium selenite in Se contaminated treatments. The total concentration applied till harvesting in each jar was 14.4 mg Se L-1. Gibberellic acid at the rate of 10 µM was applied at 5, 10 and 15 days after sowing in each jar. All the jars were arranged by following the completely randomized design with three replications under controlled conditions in growth chamber. Crop was harvested after 40 days. Study revealed that plant growth was suppressed significantly (53.4% compared to plant growing in non-contaminated sand) due to selenium toxicity. However, inoculation with different Se tolerant PGPR without application of GA improved growth and physiological parameters in selenium contamination. But more improvement in biomass (up to 76%), physiological parameters and Se accumulation in plants were observed by inoculation of PGPR in combination with GA as compared to plants growing in sand neither treated with GA, nor inoculated with PGPR.

Keywords: PGPR, phytohormone, selenium, rhizosphere

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6. Aiyesanmi, Ademola Festus

Assessing the Potential of Goat Weed (Ageratum Conyzoidies) for the Phytoremediation of Lead-Polluted Soils
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Remediation of heavy metal contaminated soil has been a serious chanllege to most developing nations of the World. In this study, Ageratum conyzoides was investigated for its potential to remediate lead-polluted soil in green house conditions, both naturally and chelate-induced. Pot experiments were conducted in nursery beds using lead spiked soils. Varing concentrations of lead salt solution were used. The plant was grown both directly on the soil and on soils modified with EDTA and Oxalic acid. The concentration of lead absorbed by the plants in the unmodified soil gradually increased with time. The maximum concentration absorbed in the root over a four-week study period was 37.12 mg/kg, while that of the shoot was 36.33 mg/kg. This increased significantly in the Ethylene diamine tetra acetic acid (EDTA) and Oxalic acid-modified soils with maximum values (Root:84.98.mg/kg, Shoot: 85.19 mg/kg) and (Root: 81.89 mg/kg, Shoot: 80.16 mg/kg) respectively. The plant growth was not affected by the increase in concentration of lead absorbed by the roots and shoots. This implies that Ageratum conyzoides exhibited a moderate tolerance for lead-contaminated soils and that of lead-contaminated soil amended with EDTA and Oxalic acid. The transfer factor ranged from 0.62 - 0.95 in unammended lead-contaminated soil; 0.75 - 1.04 and 0.84 - 0.98 in soils amended with chelating agents (EDTA and Oxalic acid respectively). Thus EDTA and Oxalic acid can be used to enhance the absorption of lead from contaminated soil by Ageratum conyzoides.

Keywords: polluted soil, lead, remediation, Ageratum conyzoides , chelating agents

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7. Akhtar, Shazia

Effect of Chelating Agents, Fungi and Native Plants in Remediation of Metals Contaminated Soils

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In present study four peri-urban agricultural areas (Multan, Kasur, Lahore and Gujranwala) in Pakistan were selected and surveyed in April 2012. Total 138 soil samples, 131 plants and 52 wastewater samples were collected. Soil and waste water samples were analyzed for their physiochemical parameters and processed for fungal isolation. Plants samples were tested for heavy metals contents. In overall assessment Pb, Cu, Cr and Cd was showing high level of contamination in the studied areas. Maximum fungal diversity was found in Multan followed by Kasur, Lahore and Gujranwala. In second phase soil shacking and incubation experiments were conducted to evaluate the changes in Cu, Cd, Cr and Pb solubility by addition of different concentration of Ethylene dinitrilo tetra acetic acid, Diethylene triamine penta acetic acid, Nitrilo tri acetic acid and fungal spore suspensions of six metals tolerant species. It was found that with increasing chelating agent doses metals availability was increased. Shaking hours of 120 and 20-30 incubation days were noticed the best optimum value for further experiments. Aspergillus species were proved best for metals solubilisation from soil matrix. In third phase in-vitro experiments were conducted growing different seed varieties of local crops e.g wheat, maize, barely, bajra, sunflower, soybean and mustard. Root and shoot biomass was recorded and heavy metal concentrations were checked plants tissues. Higher biomass production was noticed in maize and mustards crops and these plants were proved good phytoextractants for heavy metals.

Keywords: Soil, Heavy metals, Chelating agents, Fungi, Phytoremediation

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8. Ali, Shafaqat

Mannitol alleviates chromium toxicity in wheat plants in relation to growth, oxidative stress and Cr uptake in sand and soil media

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Chromium (Cr) is one of the most phyto-toxic metals in the agricultural soils and its concentration is continuously increasing mainly through anthropogenic activities. Little is known on the role of mannitol on plant growth and physiology under metal stress. The aim of this study was to investigate the mechanism of growth amelioration and antioxidant enzyme activities in Cr-stressed wheat (Triticum aestivum L. cv. Lasani 2008) by exogenously applied mannitol (M). For this, wheat seedlings were planted in pots containing soil or sand and subjected to increasing Cr concentration (0, 0.25 and 0.5 mM) in the form of of K2Cr2O7 with and without foliar application of 100 mM mannitol. Plants were harvested after four months and data regarding growth characteristics, biomass, photosynthetic pigments, and antioxidant enzymes were recorded. Mannitol application increased plant biomass, photosynthetic pigments and antioxidant enzymes while decreased Cr uptake and accumulation in plants as compared to Cr treatments alone. In this study, we showed that M applied exogenously to Cr-stressed wheat plants, which normally cannot synthesize M, improved their Cr tolerance by increasing growth, photosynthetic pigments and enhancing activities of antioxidant enzymes and by decreasing Cr uptake and translocation in wheat plants. It is concluded that M could be used to grow crops on marginally contaminated soils for which separate remediation techniques are time consuming and not cost effective.
Keywords: anthropogenic, antioxidant enzymes, chromium, mannitol, photosynthetic

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9. Ali, Shafaqat

Citric acid enhances the phytoextraction of chromium, plant growth and photosynthesis by alleviating the oxidative damages in Brassica napus L.

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The present study was performed to assess the performance of citric acid (CA) through growing Brassica napus in the phytoextraction of Cr from contaminated soil. Different Cr (0, 100 and 500 µM) and citric acid (0, 2.5 and 5.0 mM) treatments were applied alone and in combinations to four-week-old seedlings of B. napus plants in soil under wire house condition. Plants were harvested after twelve weeks of sowing and the data was recorded regarding growth characteristics, biomass, photosynthetic pigments, malondialdehyde (MDA), electrolytic leakage (EL), antioxidant enzymes and Cr uptake and accumulation. The results showed that the plant growth, biomass, chlorophyll contents and carotenoid as well as soluble protein concentrations significantly decreased under Cr stress alone while these adverse effects were alleviated by application of CA. Cr concentration in roots, stem and leaves of CA-supplied plant was significantly reduced while total uptake of Cr increased in all plant parts with CA application. Furthermore, in comparison with Cr treatments alone, CA supply reduced the MDA and EL values in both shoots and roots. Moreover, the activity of superoxide dismutase (SOD), guaiacol peroxidase (POD), catalase (CAT) and ascorbate peroxidase (APX) in shoots and roots markedly increased by 100 µM Cr exposure, while decreased at 500 µM Cr stress. CA application enhanced the activities of antioxidant enzymes compared to the same Cr treatment alone. Thus, the data indicate that exogenous CA application can increase Cr uptake and can minimize Cr stress in plants.

Keywords: biomass, Brassica napus, chromium, electrolyte leakage, guaiacol peroxidase
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10. Alka, Kumari

Growth performance, metal accumulation and biochemical responses of three fern species grown on fly ash contaminated soil

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Three fern species viz.; Pteris vittata L., Ampelopteris prolifera (Retz.) Copel. and Diplazium esculentum (Retz.) Sw. were evaluated in terms of plant growth, metal accumulation and antioxidant responses when grown on different amendments of fly ash (FA) with garden soil (GS). All the species accumulated significant amount of metals in both plant parts, fronds and rhizome including roots; however the extent of metal accumulation varied. The significant increase in biomass and photosynthetic pigments were found in the test species grown on 50 % FA amendment in comparison to 100 % GS as control but it further decreased, when 100 % fly ash was used. It indicates that 50 % FA amendment did not generate oxidative stress in ferns and seems to be suitable substratum for healthy fern growth. The activity of antioxidant enzymes, like melanoaldehydes (MDA), superoxide dismutase (SOD), ascorbate peroxidase (APX) and guaiacol peroxidase (GPX) were induced in 50:50 ratio of FA and GS, and found maximum in 100 % FA. Further, the fronds of all the species accumulated more metals than the rhizome with roots as experienced more oxidative stress, which was reflected by higher activities of anti-oxidant enzymes in frond biomass. Results showed usefulness of these species in phytoremediation of toxic metals from FA and their further implication in revegetation of FA polluted wastelands to develop dust free, healthy and sustainable environment.

Keywords: fly ash, fern, metals, photosynthetic pigments and oxidative stress

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11. Al-Lami, Mariam

Preliminary Study for Revegetation of Lead/Zinc Mine Tailings: Effect of Different Amendments on Plant Growth and Survival

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Mine tailings are of environmental concern due to the potential threat to surrounding environment arising from eolian and water dispersion of tailings. Tailings revegetation is required to stabilize tailings materials and promote in situ immobilization of heavy metals (HMs). Tailings revegetation is difficult due to poor soil properties, lack of nutrients, and elevated HMs content. Adding appropriate soil amendments should be considered to improve physicochemical and biological properties of tailings. The aim of this study was to evaluate the viability of biochar, humic substances (HS), mycorrhiza, and biosolids for their use in revegetation of Pb/Zn mine tailings with willows, poplars, and miscanthus. Three pot experiments were carried out using tailings from DOE RUN Mine 28 tailings, Viburnum, MO, U.S. The tailings are characterized by high Pb/Zn content, slightly alkaline pH, and very low organic matter. Adding 3% and 5% biochar increased tailings water holding capacity (WHC) by 9% and 16%, respectively, compared to control. While hydraulic conductivity decreased by 17% and 20% with the addition of 3% and 5 % biochar, respectively. Root and shoot biomass varied among plant species and treatments. Although HS did not increase biomass, plants looked more healthy with less leaf necrosis and chlorosis compared to control which suffered from the most severe chlorosis and necrosis. A current greenhouse experiment indicates that biosolids application at 40 dt/acre level significantly enhanced plant growth for the three species. Being the most effective amendment, biosolids will be tested for their effects on tailings fertility and HMs uptake and phytoavailibilty.

Keywords: lead/zinc mine tailings, biochar, humic substances, mycorrhiza, biosolids.

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12. Ameen, Faud

Biodegradation of engine oil by fungi from Mangrove habitat

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Pollution of land and water by petroleum compounds is a matter of growing concern necessitating development of methodologies including microbial biodegradation to minimize the impending impacts. It has been extensively reported that fungi from polluted habitats have the potential to degrade pollutants including petroleum compounds. Red Sea being treaded extensively for transport of oil is substantially polluted due to leaks, spills and occasional accidents. Tidal water, floating debris and soil sediment was collected from mangrove stands on three polluted sites along the Red Sea coast of Saudi Arabia and forty five fungal isolates belonging to 13 genera were recovered from these samples. The isolates were identified on the basis of sequence analysis of 18S rDNA gene fragment. Nine of these isolates were found to be able to grow in association with engine oil as sole carbon source under in vitro conditions. These selected isolates and their consortium accumulated greater biomass, liberated more CO2 and produced higher levels of extracellular enzymes during cultivation with engine oil as compared to he controls. These observations were authenticated by gas chromatography-mass spectrophotometry (GC-MS) analysis, which elucidated that many high mass compounds present in the oil before treatment either disappeared or showed diminished level and some smaller molecules turned up de novo after treatment with the fungal isolates.

Key words: Biodegradation; Petroleum hydrocarbons; 18 rDNA; Biomass

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13. Anjum, Nasser A.

Nanoscale-Copper Responses of Salt Marsh Halophyte Halimione portulacoides L.

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In coastal areas, estuarine and salt marsh system can be the major sink of rapidly produced, multidisciplinary used and inevitably released engineered nanoparticles, where their obvious impact on inhabiting biota, and their remediation are least explored. In this study, for the first time, the effects of nanoscale-copper oxide (nano-CuO) (<50 nm) concentrations (0, 20, 40, 80, 160 and 320 mg L-1) on the growth and the managers of cellular redox homeostasis were evaluated in salt marsh halophyte Halimione portulacoides L. under hydroponic set-up. H. portulacoides exhibited its differential sensitivity to tissue-Cu-burdens in terms of cellular redox system violators (such as $O_2^{\bullet-}$ and H_2O_2) and its managers (such as ascorbate, AsA; glutathione, GSH; AsA/DHA; GSSG/GSSG; GSH reductase; GSH peroxidase; GSH-sulfo-transferase; ascorbate peroxidase, APX; catalase, CAT). A close relationship among Cu ion release, tissue-Cu-burdens and cellular redox homeostasis was noted. This presentation will discuss and interpret the previous results to get insights into the nano-CuO-accrued phytotoxicity, and adaptive responses of H. portulacoides, and potential use of this plant in nano-CuO remediation in estuarine system.

Keywords: nanoparticles, copper, halophyte, Halimione portulacoides, cellular redox system, oxidative stress

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14. Ansari, Abid Ali

Phytoremediation: Utilizing aquatic plants for the management of contaminants in aquatic environment.

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This study mainly deals with the discussions on application of phytoremediation technology in aquatic environments utilizing aquatic plants for the removal of contaminants. There are many methods employed to clean up aquatic environment, but most of them are not as cost effective as phytoremediation. Most of the aquatic macrophytes have very high potential of phytoremediation by hyperaccumulation of inorganic and organic forms of various contaminants, with their metabolism, growth, development and reproduction unaffected. Aquatic plants are highly capable to accumulate pollutants in their root and shoot system and to form phytochelates and stabilized ions. More studies are required to observe the mechanism behind the phytoremediation of contaminants from aquatic environment, role of different environmental factors need to be determined.

Keywords: aquatic plants, contaminants, hyperaccumulators, phytochelates

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Acknowledgements: The authors would like to acknowledge financial support from the Deanship of Scientific Research (DSR), University of Tabuk, Tabuk, Saudi Arabia, under the no. S-0021-1436.

15. Bada, Babatunde Saheed

Phytotoxicity and Phytoremediation Potential of Kenaf (Hibiscus cannabinus Linn.) in Diesel-Contaminated Soil Amended with Poultry Manure and N-P-K Fertilizer

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Abstract
Remediation methods such as soil washing and excavation are not sustainable. This study determined the phytotoxicity and phytoremediation potential of kenaf (Hibiscus cannabinus Linn.) in diesel-contaminated soil amended with Poultry Manure (PM) and N-P-K fertilizer. Phytotoxicity experiment was carried-out using four kenaf varieties (Cuba 108, Ifeken 400, Ex-shika and Tianung 1) with 10 diesel Contamination Levels (CLs): 0, 1, 5, 10, 15, 20, 50, 100, 150 and 200 g kg-1 and replicated three times in Completely Randomized Design (CRD). Germination rate and growth parameter were taken to compute Emergence Percentage (EP), Vigour Index (VI) and Tolerance Index (TI). Phytoremediation experiment was 3 (diesel CLs: 0, 1 and 1.5 % w/w) × 2 (amendments: PM and N-P-K) factorial in CRD, replicated thrice. After harvesting, kenaf was separated into leaf, root, core and bast fibers. Data were analyzed using descriptive statistics (mean and standard deviation) and ANOVA. Cuba 108 had the highest number of germinated seedlings (16) with highest EP, VI and TI of 41.67 %, 345.83 and 135.971 % observed at 1, 1 and 1.5 % w/w respectively. There was significant ($p < 0.05$) difference between growth and yield parameters of the control and other CLs. Significantly ($p < 0.05$) higher Cr, Cd and Ni were observed in bast fibre at 1.5 % w / w. Highest Cr and Ni values of 21.00 ± 0.50 and 8.33 ± 1.26 mg kg-1 were observed at 1 and 0 % w/w amended with N-P-K.

Keywords: Kenaf varieties, Tolerance, Oil spiked soil, Soil amendments
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16. Bakht, Jehan

NATURAL AND ASSISTED PHYTOEXTRACTION CAPACITY OF TOBACCO CULTIVARS, THEIR GROWTH AND PROTEIN EXPRESSION UNDER HEAVY METALS CONTAMINATED SOIL

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The present study investigates the phyto-accumulating capacity, growth parameters and protein profiling of two tobacco cultivars when exposed to heavy metals and EDTA. Heavy metal along with application of EDTA had a significant effect on growth parameters (shoot length, leaf fresh weight and dry weight) and heavy metal accumulation 15 and 30 days after treatments. All growth parameters were reduced with increasing concentration of different heavy metals. Growth parameters were reduced more in dark sun cured as compared to flue cured Virginia. Application of Cr at the rate of 500 mg kg-1 revealed maximum reduction in leaf fresh weight, dry weight and shoot length. The data also showed that maximum accumulation of heavy metals was recorded in flue cured virginia compared with dark sun cured. Analysis of the proteome of the shoot tissues of heavy metal and EDTA treated and untreated plants by SDS-PAGE identified several proteins that are induced by heavy metals and/or by EDTA application in tobacco plant and which may be involved in conferring heavy metal metal tolerance. SDS-PAGE revealed that tobacco cultivars treated with different concentrations of heavy metal and EDTA induced few proteins while some proteins were expressed abundantly.

17. Bakht, Jehan

HEAVY METAL TOXICITY: IMPACT ON PLANT DEVELOPMENT AND METAL UPTAKE BY WHEAT VARIETIES (Ghaznavi-98 and Siren)

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2 Department of Agronomy, The University of Agriculture Peshawar KPK Pakistan considered as a potential hyperaccumulator plant variety.
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This study investigates the effect of heavy metals and EDTA on the plant development and heavy metals uptake by wheat (Triticum Aestivum L.) cultivars, that is, Ghaznavi-98 and Siren. The results revealed that heavy metals and EDTA exposure had significantly affected plant physiological traits such as shoot length, fresh weight, dry weight and also its ability to accumulate heavy metals. A trend of reduction in plant growth was noticed when heavy metals (Cd, Cr and Pb) were applied in increasing concentrations. Maximum decrease was noted in Cd treatment at 40 mg.kg-1. However, minimum reduction was measured when treated with 100 mg Pb kg-1, showing that these plants are more tolerant to lead. The statistical data also revealed that application of EDTA (5mM) had significantly increased heavy metal accumulation in plants especially Siren. A general pattern of increase in heavy metal accumulation was observed when heavy metals were applied in increasing concentrations. The data depicted that maximum uptake was noted at 200 mg Pb kg-1. The outcome of this study corroborated that heavy metal uptake was enhanced by the application of EDTA and also had a drastic significant effect on plant physiological characteristics. Furthermore, amongst cultivars, Siren can accumulate more heavy metal in their tissue and can be used for decontamination of heavy metal polluted soil and thus can be considered as a potential hyperaccumulator plant variety.

18. Balcom, Ian

Microbial ecology of an ecological wastewater treatment plant: insights intopharmaceutical removal processes.

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The effects of environmental contamination by pharmaceuticals and personal care products (PPCPs) have received significant attention in recent years. Due to their widespread use, incomplete removal during wastewater treatment, contamination of aquatic environments, presence in municipal drinking water, and regulatory status, this diverse class of pollutants may represent a significant risk to people and the environment. While PPCP removal processes in conventional wastewater treatment plants have been thoroughly examined, few studies have examined PPCP removal processes in engineered ecological wastewater treatment systems (Eco-Machines®). Ecological wastewater treatment systems utilize microbial metabolic processes to treat aqueous wastes including human wastewater. However, the microbial ecology of these systems has not been described. To address these gaps in knowledge of the functioning of ecological wastewater treatment systems, the microbial ecology an Eco-Machine® treating human wastewater at an interstate rest area in central Vermont was characterized using culture-independent next-generation DNA sequencing methods. Genomic DNA was extracted from aqueous and plant root-associated immersed biofilm phases of each component of the wastewater treatment system. Additionally, the aqueous phase concentration of PPCPs in each of the system components was quantified. By employing bioinformatic characterization of the translated DNA sequences, the taxonomic and metabolic diversity of the system's microbiome was characterized. A greater abundance and diversity of both microbial genera and xenobioticmetabolizing genes was identified in the plant-associated immersed biofilm samples. Additionally, the immersed biofilm samples showed greater phylogenetic and metabolic variability than the aqueous phase samples. These results indicate plant root associated microbial populations are driving aqueous PPCP biodegradation in ecological wastewater treatment systems. Moreover, differences in phylogenetic and metabolic diversity between samples collected from separate locations with identical phyiochemical conditions indicate plant selection may be influencing aqueous PPCP biodegradation.

19. Barden, Charles

Phytoremediation Case Studies in Manhattan, Kansas

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Phytoremediation case studies at two sites in Manhattan, Kansas were conducted; the KSU Old Chemical Waste Landfill; and Biosolids Disposal Farm, operated by the City of Manhattan. The remediation goal at the KSU Old Chemical Waste Landfill is to get hydraulic control of a polluted groundwater plume, using trees to take up and transpire 1, 4 Dioxane. Several rows of poplar, Populus species, were deep planted to facilitate root growth to a greater depth in the heavy clay loam soil, to enhance the probability of pollutant uptake from the shallow groundwater. Additional rows of trees were also established down gradient. The remediation goal at the Biosolids Disposal Farm was to establish a tree root barrier to reduce the flow of nitrate-rich groundwater into the Kansas River, with a three row planting established in 2004. In 2006, a trench study was installed to improve tree establishment on a sandy outwash area where an earlier tree planting had failed. Siberian elm, Ulmus pumila, and two sources of cottonwood, Populus deltoides, were planted. Treatments included trenching, composted manure, and tree shelters. There were significant interactions between the treatments on planting stock performance, but the planting was successfully established. An average-sized cottonwood from the 2004 planting was excavated at age 10, and was found to be rooted to a depth of 18', close to the water table.

Keyword: nitrate, dioxane, biosolids, cottonwood, Populus

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21. Bokhari, Syeda

Phytoremediation Potential of Lemna minor L.
for Heavy Metals

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Conventional remediation methods of waste water treatment are expensive and are not environment friendly. A glass house experiment was conducted to evaluate the phytoremediation potential of Lemna minor for cadmium, copper, lead and nickel by growing in raw sewage mixed industrial effluent and municipal effluent for a period of 31 days. Plant and water were sampled periodically from experimental tubs at days 3, 10, 17, 24 and 31 and were analyzed for heavy metal concentration. Phytoremedial parameters, i.e., percentage removal efficiency, metal uptake and bio concentration factor were calculated. Results of physical, chemical and microbiological composition showed that municipal effluent was more contaminated in terms of organic and nutrient load. Heavy metal concentration in the effluents was decreased with increasing exposure time and significant differences were found between initial and subsequently sampled water. Heavy metal concentration in plant was also increased and uptake of lead (Pb) was significantly higher ($p < 0.01$) than other metals. Removal efficiency (%) of plant was greater than 80 percent for all heavy metals. Maximum bio concentration factor values were observed for copper and lead which were 558 and 523, respectively. L. minor demonstrated the ability to remove heavy metals from both types of effluent and high removal percentage and metal uptake capacity give evidence of its phytoremediation efficacy.

Keywords: industrial and municipal effluents, heavy metal, phytoremediation, duckweed, metal uptake

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22. Boyer, Will

Vegetative Buffer for Treating Surface Runoff from Livestock Confinement Facilities in Kansas

Will Boyer, Kansas State University Research and Extension

Vegetative buffers are used in Kansas to treat runoff from livestock facilities which do not have state or federal permits. Permits are required of facilities having at least 1,000 animal units or having "significant water pollution potential." Regardless of size, any facility with a waste storage structure or piped discharge is considered a significant pollution potential. Confinement facilities without a permit are expected maintain an adequate vegetative buffer to avoid having significant pollution potential. Eleven surface water pollution potential factors are used to evaluate the adequacy of a buffer. Animal units, utilization period and pen slope are factors related to the amount of waste which could runoff from a pen. Annual rainfall, 25 year/24 hour storm, and extraneous drainage are factors influencing the amount and intensity of water which could carry waste downstream. Vegetation type, soil type, and the size of the buffer in relation to the size of the pen area are buffer treatment factors. And finally, distance to protected water body and slope to protected water body are factors related to the chance that pollutants could impact a classified stream. Each factor is ranked on scale from 1-9 or 1-10 and the score for all eleven factors are summed. If the total is 60 or less then the facility is considered to have an adequate buffer. This system is applied statewide but it is only a guide to for evaluating surface water pollution potential. A number of other things are considered in determining Kansas water pollution potential.

Key words: buffers, decision support, regulation, water quality, livestock waste

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23. Bradfield, Scott

Accumulation of metal oxide engineered nanoparticle in sweet potato

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The increased production of engineered nanoparticles (ENPs) has raised concern about their potential release into the environment, both intentionally and unintentionally. There are several avenues of exposure for ENPs to come in contact with plant foods. Of plant foods, root vegetables have the greatest likelihood of taking up and accumulating ENPs due to their direct contact with soils. A suite of metal oxide ENPs and their ionic counterparts were used to evaluate the uptake and accumulation of metal oxide ENPs in sweet potatoes. The sweet potatoes were grown outdoors in 6 quart pots containing a mixture of potting mix, perlite, and sand treated with four concentrations of the ENPs and ions (0, 100, 500, and 1,000 mg kg-1). The leachate from the pots was collected and recirculated to prevent the loss of ENPs or ions through leaching. After harvest, tubers of similar dimensions were selected to be processed for elemental analysis. Additional steps were made to examine whether common food preparation steps alter metal oxide ENP dietary exposure. Dietary exposure modeling will be used to determine the potential nutritional bioaccessibility of the metals from the ENPs in the sweet potatoes. In order to provide a comprehensive assessment of the potential food safety risk posed by metal oxide ENPs, the nutritional bioaccessibility of the metals from the ENPs will be demonstrated and models projecting dietary exposures will be produced. Future work with the remainder of the tissues may be used for a physiologically based extraction test (PBET) to gain additional knowledge on how metal oxide ENPs may affect the nutrition.

Keywords: engineered nanoparticles, food safety, dietary exposure

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24. Burken, Joel

Novel Plant Sensing of Landfill Flaws for Ecological and Human Health Benefits.

Joel Burken, Missouri University of Science and Technology*, Rahul Sukharia, Missouri University of Science and Technology; Danielle West, Missouri University of Science and Technology; Jordan Wilson, Missouri University of Science and Technology, and Tommy Goodwin, Missouri University of Science and Technology

The scale and number of landfills in the US is staggering, and many were closed long before current regulations (RCRA) worked to limit what was placed in landfills and how landfills were constructed, operated and closed. As a result we have a vast number of waste repositories that are not a question of 'will they impact environment and human health?' the question is 'When and how?'

Novel methods of plant sensing have been used to delineate leachate plumes, including hydrocarbons, chlorinated compounds, and inorganics. Current and past approaches will be overviewed in this talk. A specific case study will be presented, where large areas of urban, industrial and active landfilling areas were assessed for multiple organics and radionuclides. Current research methods are looking at assessing plant health with remote sensing and aerial-based scanning of large areas to assess leachate plumes, seeps, and gas emissions. These methods could streamline problem identification long before traditional methods would have been enacted to determine leachate or emissions. Methods can also be integrated with living ECaps that are now approved for mitigating percolation and treating collected leachate. The speed, large spatial scale and reduced costs offered with integrated plant assessments are protective of human health and preventative of ecological impacts.

Keywords: landfill leachate, plant sensing, phytoforensics,

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25. Burken, Joel

Phytoforensic Detection of Subsurface Geochemistry Reactions: Field, Laboratory and Classroom Applications

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Plants are well known to transport both organic and inorganic chemicals from the subsurface, which is beneficial in assessing the spatial extent of subsurface pollutants. However this transport also provides insight to the potential for subsurface degradation, when assessing the presence of parent compounds and also metabolites (i.e. daughter products). At numerous field sites the presence of daughter products and ratios of degradable to recalcitrant compounds are indicative of subsurface reactions and reaction rates.

A set of laboratory and field experiments were also conducted, revealing a correlation of in-planta concentrations with degradation process in the subsurface. Reactions were noted for both BTEX hydrocarbons and chlorinated solvents and for both microbial degradation and for abiotic reactions. The potential applications offer an additional line of evidence for natural attenuation applications and increasing the acceptance of low-impact remediation approaches.

The methods were also utilized in classroom settings, showing potential of using plant uptake studies to teach plant-contaminant interactions, trans-membrane, geochemical reactions, vapor intrusion potential, and analytic chemistry. Methods were successful to demonstrate the impact of engineered degradation zones without testing soil or groundwater.

Keywords: Geochemistry, natural attenuation, plant sensing, phytoforensics

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26. Canfield, Jessica

Green Infrastructure Demonstration and Training: Monitoring and Interpreting Two Sites on the Kansas State University Campus

Jessica Canfield, Kansas State University (KSU-LARCP)*; Stacy Hutchinson, KSU-BAE;
Katie Kingery-Page, KSU-LARCP; Lee R. Skabelund, KSU-LARCP.

As educators, designers, and stewards of the land, we view green infrastructure projects as part of a larger ecological restoration effort. We seek to "address issues of ecological degradation, biodiversity loss, and sustainability science simultaneously" to engender a holistic perspective in regards to restoring hydrologic and ecological functions (Clewell & Aronson 2007, p.1). Having holistic restoration as our stretch-goal helps citizens achieve positive changes in their neighborhoods, cities, and eco-regions. Small sites influence larger systems and vice versa, and given that essentially all work related to conserving and enhancing ecological functions begins on some type of site, we should aim to make a positive difference on all sites regardless of their size. Such sites can significantly improve ecosystem services in urban areas and do so in beautiful and engaging/educational ways (Echols & Pennypacker 2008; Liptan & Murase 2002; Grant 2012). Our overall project goal is to utilize K-State's ISC Rain-Garden and Beach Museum Meadow sites as living laboratories (Duschl et al. 2007), where faculty and students can monitor and interpret the multifaceted performance benefits of green infrastructure. In doing so we will engage an interdisciplinary team of undergraduate students, including students in Landscape Architecture and Biological and Agricultural Engineering courses in developing and implementing a monitoring program; in collecting and analyzing landscape performance data; and in documenting and disseminating findings and lessons learned (building on Moore et al. 2012). This presentation describes the range of activities that our interdisciplinary project will entail and the tangible educational results of the project.

Keywords: green infrastructure, monitoring hydrology and ecosystem services, sustainable campus design and management; student and community engagement/learning

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27. Chaney, Rufus L.

Effect of Soil Volume on Yield of and Ni Hyperaccumulation by Alyssum corsicum.

Ilya Baklanov, University of Maryland, Dept. Civil & Environ Eng., College Park, MD; Thomas C. Ryan, Paint Branch High School, Burtonsville, Maryland; Rufus L. Chaney*, USDA-Agricultural Research Service, Crop Systems and Global Change Lab, Beltsville, MD; and Allen P. Davis, University of Maryland, Dept. Civil & Environ Eng., College Park, MD.

Plant uptake of some nutrients is limited by the diffusion of an element from soil surfaces binding the nutrient to the root cell membrane where absorption occurs. For such nutrients, plant uptake can be strongly limited by the plant root surface area. Ni concentration in soil solution of ultramafic soils is quite low (about 0.8 µM in saturation extract of the Brockman variant silt loam from Josephine Co., Oregon; total Ni = 4700 mg/kg), yet Alyssum Ni hyperaccumulator species growing on this soil in the field accumulate 1.5-2% Ni in dry shoots and support commercial phytomining of Ni.

In order to better understand the effect of soil volume on Ni hyperaccumulation by A. corsicum from Ni rich ultramafic soil we conducted a test of the growth and Ni and nutrient accumulation in the shoots of plants grown for 60 days in a greenhouse. Soil mass in the pots varied from 274 g (8 cm diameter, 7 cm tall), 593 g (10 cm by 8 cm), 1.39 kg (13 cm by 12 cm), 2.24 kg (15 cm by 13 cm), 4.90 kg (20 cm by 16 cm) to 8.57 kg (23 cm by 20 cm) using plastic pots. Yields were 0.56±0.18 g, 0.63±0.24 g, 3.16±0.37 g, 6.48±1.62 g, 5.81±0.90 g, and 5.27±0.30 g in the series of pot sizes, and shoot Ni concentration was 2.22±0.50 g/kg, 1.31±0.35 g/kg, 4.22±0.75 g/kg, 6.86±0.95 g/kg, 7.48±0.28 g/kg, and 9.38±0.86 mg/kg dry biomass. Yield of Ni was 0.70±0.22, 1.01±0.46, 11.4±2.4, 40.2±4.6, 43.8±8.1 and 49.5±5.4 mg/pot showing the remarkable effect of pot/soil volume on growth and Ni hyperaccumulation by A. corsicum.

The present study shows the importance of rooting volume to Ni hyperaccumulation, and to research on Ni phytomining technologies. These findings are likely to be relevant to other soils and species where the element being studied is strongly bound by soils and is obtained by diffusion soil from sorption sites to root surfaces.

Keywords: Phytoextraction, Hyperaccumulation; Nickel, Alyssum, Diffusion.

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28. Chaudhary, Hassan

Influence of endophytic Bacillus pumilus and EDTA on the phyto-extraction of Cu from soil using Cicer arietinum

Hassan Javed Chaudharya*, Amnaa

Plants possess promising remediation potential for metal-contaminated soils particularly in response to application of growth promoting bacteria and metal chelators like ethylenediaminetetraacetic acid (EDTA). Current study was designed to screen out the nested belongings of Cicer arietinum and Bacillus pumilus (KF 875447) at different copper (Cu) levels and their potential to deal with Cu uptake from contaminated soils. A pot experiment was carried out by examining soil containing C. arietinum seedlings either inoculated with B. pumilus or un-inoculated plants along with 5mM EDTA. Plants were subjected to three different concentrations of Cd (i.e., 250, 350, and 500 ppm) for 48 days. An increase in Cu uptake was observed for C. arietinum plants inoculated with B. pumilus than un-inoculated plants. Among the different treatments, C. arietinum showed improved values for different growth parameters in presence of B. pumilus, root length (37 %), shoot length (31 %), whole fresh and (45 %), dry plant weight (27 %), and chlorophyll contents (32 %).Based on shoot and root tolerance indexes, > 70% of metal (500 ppm) tolerance was observed in C. arietinum. Application of B. pumilus and EDTA significantly enhanced metal accumulation by plant up to 19% and 36% respectively. While both in combine increases metal accumulation up to 41%. Bioaccumulation and translocation factor revealed that plant can phyto-extract Cu, and this ability is helped when inoculated with B. pumilus. Futhermore, EDTA improved metal accumulation ability of plant purely reflected its role as a strong chelating agent, sequestering metal ions with diminishing toxicities.

Key words: Cicer arietinum; Bacillus pumilus; Phytoremediation; EDTA; Copper

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29. Clausen, Lauge

Aerobic TCE degradation by willows and three root colonizing Bacterial strains of B. cepacia

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Trichloroethylene (TCE) is a widespread soil- and groundwater contaminant constituting a potential risk to humans and environment. Clean-up of TCE contaminated sites is often problematic and expensive. If possible, phytoremediation may be a cost-effective solution. The present study investigates TCE degradation rates by willows (S. viminalis) with and without three bacterial strains of root colonizing Burkholderia cepacia (B. cepacia 301C, PR1-31 and pTOM). Willows were grown hydroponically for 3 weeks in modified ISO 8692 nutrient solution, pH approx. 8, with minimized chloride content. Plants were exposed to 5 and 10 mg TCE/L and refilled with TCE solution weekly. Transpiration was monitored as health indicator of the trees. TCE mineralization was tracked by formation of Cl-. Preliminary results show that willows alone do not, or with a small rate, degrade TCE. However, we expect that their associated rhizospheric microbes, the three strains of B. cepacia, can degrade or co-metabolic degrade TCE under aerobic conditions. Degradation rates will be presented, discussed and compared with literature findings. The experiment is expected to clarify whether phytoremediation of TCE with and without rhizobacteria such as B. cepacia is feasible or not. Furthermore, this simple experiment allows us to screen for potential TCE degrading and root-colonising bacteria applicable for bio-enhanced phytoremediation.

Keywords: TCE; degradation; phytoremediation; Burkholderia cepacia 301C, PR1-31 and pTOM.

30. Conklin, Karah

Lessons Learned from the Long-Term Monitoring and Management of a Large Scale Phyto Plot

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

Roux Associates, Inc. installed a 42-acre phytoremediation plot at a former petroleum refinery in Rhode Island to address petroleum residuals and dissolved phase groundwater impacts. A mixture of deep-rooting phytotechnology species (hybrid poplar and black willow) and native species (green ash and red maple) were installed to promote rhizodegradation of residual organics, phytostabilization of metals (i.e., lead), and hydraulic control of groundwater via evapotranspiration mechanisms. A pilot plot consisting of 130 trees was installed in 2000 to demonstrate the applicability of the technology to the Site and the full-scale installation of the 15,000 tree phyto plot was conducted in 2009.

This presentation will address the lessons learned from the implementation, monitoring and maintenance the pilot and full scale phytoremediation plots over the last 15 years including:

- Project Planning – What are the challenges of implementing a large plot based on a pilot scale test?
- Implementation – How do you balance costs while ensuring proper implementation?
- Monitoring – How do you cost effectively monitor 15,000 trees and produce usable data to determine plot performance?
- Maintenance - How do you cost-effectively manage 42 acres of trees on a semi-remote site?
- Performance – How does the full-scale plot performance compare to the pilot plot performance? How do biotic and abiotic factors (e.g., drought, insect infestation, etc.) affect plot performance? Has the phyto plot been able to achieve the project objectives?

Keywords: phytoremediation, petroleum, long term results

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31. Conklin, Karah

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

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32. Coulon, Kelly

Sustainable Wastewater Treatment:
Using Natural Systems in the Middle East

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

Water is a particularly important resource in the Middle East, where fresh water typically comes from desailnation plants. Roux Associates designed a natural wastewater treatment solution for a 3,000 acre new industrial facility in Saudi Arabia.

The 23-acre treatment system was designed to manage sanitary wastewater, process wastewater, and stormwater for a combined total flow of 2 million gallons per day. The major system components include: primary sedimentation and anaerobic treatment tanks, enhanced horizontal subsurface flow constructed wetlands to degrade organics and nitrogen, downflow soil filters for disinfection and phosphorus removal, a backup UV disinfection system, a treated water holding tank and pump station to convey water to the facility for 100% reuse, and activated alumina filters to remove fluoride from stormwater runoff. The effluent from the treatment system is reused in the manufacturing process and for irrigation, thus reducing water demand by over 2 million gallons per day and saving more than $7 million annually that would otherwise be used to purchase fresh water.

Keywords: treatment wetland, CTW, Middle East, industrial, wastewater

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33. Cutting, Angela

Stacking it Up: Combining Gravel Infiltration Basin and Constructed Treatment Wetland for Process and Storm Water Treatment in San Jose, California

Angela Cutting, Ph.D., P.E., Roux Associates, Inc.*; Bjorn Wespestad, P.E., Roux Associates, Inc.; Nicole Rodriguez, Roux Associates, Inc.; Phyllip Nguyen, P.E., San Jose Water Company; Francois Rodigari, San Jose Water Company

An innovative and green design for well blow-off water and storm water treatment was engineered and implemented in San Jose, California. The approach utilized constructed treatment wetlands to maximize evapotranspiration, treatment and infiltration of storm water runoff generated from a 3-acre site. In addition to storm water, the CTW also treats and manages well blowoff water (up to 1,350 gallons per minute) from SJWC's meter testing facility.

The final design is a sump pond treatment system providing the following primary treatment mechanisms: 1) eight-feet gravel media for filtration of total suspended solids and associated metals; 2) two-feet deep surface CTW on top of the gravel filter for the treatment of biological oxygen demand, ammonia, and petroleum compounds; and 3) three-feet of free board for temporary storage during storms and well blowoff events.

The CTW is comprised of shallow marshes and open water gravel channels. All water inputs are piped to the gravel filter at the bottom of the CTW and daylight in the gravel open water channel if the inflows exceed the infiltration capacity of the sump. The shallow marshes aid in the storm water treatment by impeding flow and trapping contaminants. The vegetation, which includes wetland species tolerant of both wet and dry conditions, stabilizes and protects deposited sediments from resuspension during large storm events. The construction was completed in February 2015 and the treatment system is in full operation.

Keywords: constructed wetlands, storm water, gravel filter

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34. Dahmer, Carolina

DDT Remediation at Point Pelee National Park: Hydroxypropyl-β-Cyclodextrin and Phytoextraction Approaches

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Point Pelee National Park (PPNP) is heavily contaminated with dichlorodiphenyltrichloroethane (DDT). This pesticide was widely used for mosquito and pest control in the Park from 1948 to 1967. Since the 1990's when the presence of DDT was discovered in tissue samples from the Park's wildlife, DDT has become a major concern for Parks Canada personnel. The focus has been on remediation techniques that will not interfere with the ecological integrity of the Park. These techniques have included phytoextraction of DDT by crop species, Curcubita pepo, and native plant species, including Panicum virgatum and Schizachyrium scoparim, as well as the use of hydroxypropyl-β-cyclodextrin (HPβCD) to increase DDT solubility and microbial degradation. HPβCD is not commonly used in remediation, however early experimentation by previous studies presented optimistic results. They reported removal of up to 90% DDT from surface soils at the experimental site, and suggested that the decrease in DDT concentration was due to enhance in-situ biological degradation. A re-examination of their data suggests that HPβCD could actually be mobilizing DDT into the groundwater, rather than enhancing its degradation. Moreover, there is no solid evidence that microbial degradation of DDT increased due to HPβCD application. Although both remediation methods have been tested at pilot-scale in PPNP a possible combine approach is yet to be investigated. The present study focuses on understanding the true role of HPβCD in DDT remediation and the possibility of combining its use with phytoextraction.

Key words: DDT, hydroxypropyl-B-cyclodextrin, phytoextraction, soil

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35. Dan, Yongbo

Characterization of Gold Nanoparticles Uptake by Tomato Plants Using Single Particle Inductively Coupled Plasma-Mass Spectrometry

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Plants, as one of the most important ecological receptors as well as food sources for humans and wild lives, play a critical role in the fate and transport of engineered nanoparticles (NPs) through NPs uptake and bioaccumulation. Interactions between engineered NPs and plants, especially food plants, constitute a significant part of the risk assessment of engineered NPs in the environment. Unfortunately, current technologies are limited to reveal the concentration and unique characteristics of NPs once they enter into plant tissues. A novel enzymatic digestion method, followed by single particle inductively coupled plasma-mass spectrometry (SP-ICP-MS) analysis was evaluated for simultaneous determination of gold NP (AuNP) size, size distribution, particle concentration, and dissolved Au concentration in tomato tissues. NexION 300/350D ICP-MS with Syngistix™ NanoApp module the market only dedicated software for SP-ICP-MS was used for the data collection and handling. The experimental results showed that Macerozyme R-10 enzyme digestion was capable of extracting AuNPs from tomato tissues without causing dissolution or aggregation of AuNPs. The quantitative AuNP size detection limit of the developed SP-ICP-MS method was 20 nm and the AuNP particle concentration detection limit was 1000 NPs/mL. The particle concentration recovery of spiked AuNPs was high (79%-96%) in quality control samples. The developed SP-ICP-MS method was able to accurately measure AuNP size, size distribution, and particle concentration in tomato plant matrix. The dosing study indicated that tomato can uptake AuNPs as intact particles without alternating the AuNPs properties.

Key words: single particle-ICP-MS, nanoparticle uptake by plant, gold nanoparticle in tomato, Macerozyme R-10 enzyme

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36. Daniel Garcia-Mercado, Hector

Phytoremediation research on contaminant fate: Mercury in Mexican polluted soils

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Mexico produces mercury and its mining has contaminated neighboring soil sites. The aim of this research was to evaluate mercury´s fate in lab scale artificial wetlands considering the following mercury species: soluble, interchangeable, strongly bound, organic, and residual ones. Soil samples from two former mercury mines, "La Lorena" and "San José", belonging to the Municipality of Pinal de Amoles, Querétaro, México (N 20° 58' to 21° 21' and West 99º 26' to 99° 43') were studied during 36 weeks using ex-situ lab scale artificial wetlands. Initial mercury contents were of 424.71±29.16 and 433.38±12.02 mg kg-1, respectively. Typha latifolia and Phragmites australis were used to evaluate its biochemical response using 20 reactors (2 with each soil sample and each hydrophyte one control without plant and its replicas). The reactors were weekly fed with a nutrient solution containing a suitable N:P:K ratio for each plant, that for simulating rain conditions in that area had a pH value of 5.0. Mercury removal rates for both systems were of 55-78% for T. latifolia and 58-82% to P. australis. Mercury fate was assessed through an overall mass balance that indicated there are mercury emissions to the atmosphere.

Key Words: Mercury fate, Mexican polluted soils, Phytoremediation, Typha latifolia, Phragmites australis

37. Desjardins, Dominic

Species assemblage promotes functional complementarity for remediation of multi-contaminated brownfield

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Phytoremediation needs to overcome obstacles to be considered as a viable alternative by brownfield landowners and stakeholders. Knowledge about several plant and microorganism remediation abilities is now available for scientists and practitioners to implement, but most of it is derived from single plant species trials. In addition, ecosystems are considered to be productive, resistant and resilient to stress because their components fulfill complementary functions. We think a functional diversity approach, which would promote expression of relevant remediation functions sought for gentle remediation approaches, should therefore be adopted for phytomanagement of brownfield soils.

A mesocosm experiment including all possible three species combinations (i.e. Salix miyabeana, Medicago sativa and Festuca arundinacea in mono and co-cropping) in a brownfield soil co-contaminated with Ag, Cu, Zn, PAHs and PHs was conducted during the summer of 2014. The first results available confirm equal yields in some of the co-cropping treatments compared to equivalent monoculture densities.

Complementary trace elements bioaccumulation and organic pollutant degradation are used to assess the remediation efficiency. Data regarding root functional traits, proportion of TEs labile pool and microbial community diversity will be obtained in the upcoming months. This will allow us to describe the functionality of our diverse plant-systems exposed to a multi-contaminated brownfield soil.

Our integrated approach aims to detail how a strategy that takes advantage of biodiversity can be beneficial for phytoremediation initiatives in terms of ecological functioning, sustainability and remediation efficiency.

Keywords: remediation, functional complementarity, designed plant-system, diversity, phytomanagement

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38. Dhankhar, Om Parkash

Rice Plasma Membrane Intrinsic Proteins Play Critical Role in Arsenite and Boron Transport and Providing Tolerance in Plants

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Metalloid arsenite (AsIII) and boron (B) are phytotoxic and cause severe decline in crop productivity worldwide. Rice accumulates high level of arsenic (As) in its edible parts and thus plays an important role in the transfer of As into the food chain. However, the mechanisms of As uptake and its detoxification in rice are not well understood. Recently, Silicon transporters belonging to the Nodulin 26-like Intrinsic Protein (NIP) subfamily of plant aquaporins were shown to transport AsIII and B in rice and Arabidopsis. However, rice requires 10-12% silicates for the mechanical strength and stress tolerance. Therefore, blocking the function of NIP to reduce AsIII and B accumulation in rice will severely compromise rice growth and yield. To identify genes specific to AsIII and B transport in rice, we analyzed the role of the Plasma Membrane Intrinsic Proteins (PIPs) subfamily of aquaporins for their involvement in AsIII and B transport and tolerance. We provided experimental evidences showing that members of rice PIP subfamily are involved in AsIII and B permeability in plants. Heterologous expression of rice PIP in Xenopus laevis oocytes confirmed their role in AsIII transport. Further, expression of rice PIP genes in yeast strain lacking the metalloids influx and efflux systems resulted in an increased B sensitivity and accumulation. Overexpression of rice PIP genes in Arabidopsis yielded enhanced AsIII and B tolerance without causing an increase in As and B accumulation. Short-term influx and efflux assay for AsIII and B transport suggested a bidirectional transport activity of rice PIPs. Our results clearly showed that PIPs genes will be highly useful in developing AsIII and B tolerant crops for enhanced yield in the areas affected by high As and B toxicity.

Key Words: aquaporins, arsenite, boron, toxicity, plasma membrane intrinsic proteins

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39. Dickinson, Nicholas

Restoration Rhizosphere Phytotechnologies: Case Studies in New Zealand's HMEs

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Phytotechnologies use plants to resolve environmental problems through remediation and restoration of Human-Modified Ecosystems (HMEs) on soil templates that often have been profoundly modified from their natural condition. Understanding the dynamics of the rhizosphere, and linkages between soil physico-chemistry and below-ground biodiversity is essential to finding sustainable solutions. In studies described here, simple experimental mesocosms in the laboratory and glasshouse are used to demonstrate the importance of the rhizosphere to soil structure and pollutant mobility. New Zealand field studies are then described that include conversion of a lowland plantation forest to a mosaic of intensive irrigated dairy farming interspersed with plots of natural dryland vegetation. We describe how the physico-chemistry of soils has been modified, linking this with the challenges of managing the restoration trajectory as a phytotechnology application. Experimental results show a significant interplay between native plants, rhizospheres and earthworms that both significantly modify and are influenced by soil hydrology, pH, and soil biogeochemistry (including soluble and gaseous nitrogen). We argue that large potential gains through restoration phytotechnologies are feasible. Some 50% of New Zealand's land area supports an agricultural matrix with depauperate native vegetation. Selection of plant traits from a unique biodiversity palette together with inoculation of native species of earthworms provide an opportunity to resolve some of the environmental constraints currently impacting agriculture, thereby future-proofing and adding value to agricultural production systems. We have the capability to effectively re-create native but novel ecosystems for pollution management on human-modified soils.

Keywords: soil chemistry, roots, earthworms, pollutants, ecosystem services

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40. Dogdu, Gamze

Phytoremediation of real denim-dying textile wastewater in a vertical flow constructed wetland model using of zeolite and pumice stone media

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Textile effluents, most of the natural and synthetic textile dyes are resistant to degradation and decolorization by conventional treatment methods. Constructed wetlands (CWs) have been used as an innovative green technology to treat various industrial wastewaters in recent years. The main aim of this study was to treat organic pollutants, nutrients and color present in real denim-dyeing textile wastewater by the use of low-cost CW systems at different reactor depth points. A vertical flow constructed wetland model comprising four different bedding materials, which were sand, gravel and zeolite and pumice stone. For the first time real denim dyeing and manufacturing facility effluent was treated by pumice stone-zeolite combination in constructed wetland systems to develop NH4-N and PO4-P removal efficiencies. The role of wetland plants was assessed through comparing treatment performance efficiencies between an unplanted and vegetated with Canna indica and Typha angustifolia beds. Concentration based average treatment performance for Control (R1), C. indica (R2) and T. angustifolia (R3) reactors for the selected pollution parameters were COD; 75.45±26.76, 79.71±28.01, 72.36±30.68 mg/L Color; 76.57±27.58, 87.05±37.54, 76.67±34.40 Pt/Co NH4-N; 2.02±0.46, 2.11±0.41, 1.95±0.50 mg/L T-N; 19.5±9.69, 18.1±9.15, 17.2±8.51 mg/L and PO4-P; 0.19±0.04, 0.20±0.05, 0.17±0.021 mg/L, respectively. The effluent results were found to be below the values given in the Water Pollution Control Regulation implemented in Turkey. Overall, the results clearly demonstrated that VFCW could offer an advantageous solution to meet the Turkish Environmental Legislation for effective, low-cost and ecological textile wastewater treatment in contrast to applied conventional method in the textile plant in Turkey.

Keywords: Vertical flow constructed wetland (VFCW), real textile wastewater, zeolite, pumice stone, pollutant removal

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42. Ebbs, Stephen

Early Development of Sandhill Fen: Plant Establishment, Community Stabilization, and Ecosystem Development on Oil Sands Soft Tailings

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The excavation of bitumen from the oil sands regions of western Canada has a disruptive influence on the natural ecosystems of the region and creates a significant challenge for reclamation efforts. In particular, the removal of the naturally occurring peatlands represents a loss of one of the world's largest carbon sinks. Working cooperatively with a major oil sands company, a project is underway to evaluate strategies for re-establishing peatlands above soft tailings from the oil sands mining. The Sandhill Experimental Watershed is a 50 ha artificial wetland/upland complex north of Fort McMurray, AB. Within this watershed, a 17 ha area represents a constructed wetland where a layer of stockpiled peat has been established over the high saline oil sand soft tailings. The restoration trajectory of this fen complex is being monitored to evaluate the establishment and early performance of select native plant species established in the fen in comparison to plants growing naturally at references sites. The constructed wetland was first wetted four years ago, and ongoing efforts have been tracking water and air quality, plant community assembly and plant performance, and carbon cycling. Heterogeneity in moisture and physicochemical conditions within the wetland complex will be discussed along with data on the stability and performance of the wetland since its establishment. The lessons learned that can be applied to the next generation of wetland restoration on oil sands soft tailings pits will also be discussed.

Keywords: oil sands, peat, peatlands, reclamation, restoration, salinity, sodium

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43. Ebbs, Stephen

Dissolution of metals from automotive brake pad wear debris: Impacts on plant growth and stability of aquatic communities

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Automotive vehicles release particulate matter into the environment when their brakes are applied. The environmental effects of this automotive brake pad debris (BPWD) is a matter of growing debate yet the effects on plants have been largely untested. Recent studies have demonstrated an effect of BPWD on the growth of the aquatic invasive Salvinia molesta. Salvinia molesta plants were grown hydroponically in the absence or presence of BPWD. Growth of floating leaves, submerged leaves, and leaf nodes were measured over 20 days at 4-day intervals. The metals in solutions and plant tissues were quantified using atomic absorption spectrometry (AAS). Cultivation of S. molesta in the water containing BPWD resulted in greater dissolution of Cu and Fe than occurred in the absence of plants. The tissue Cu and Fe concentrations of plants cultivated in the BPWD were significantly higher than plants grown in the absence of BPWD. Growth of S. molesta significantly increased when cultivated in the BPWD solutions in comparison to the distilled water. The results suggest that S. molesta and similar aquatic plants may be capable of increasing the dissolution of metal micronutrients from BPWD and utilizing those micronutrients to increase growth. Such growth responses could indicate that BPWD could interact with invasive floating macrophytes to further degrade the quality and stability of aquatic communities. Ecological implications stemming from the presence of BPWD will be discussed, along with additional data demonstrating effects of BPWD on root growth and development in terrestrial plant species.

Keywords: heavy metals, brake pad wear debris, particulate matter, invasive species

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44. Esmaeili, Akhba

Marine in Industrial Biotechnology: Biosorption by Sargassum glaucescens brown algae nanoparticle at new membrane reactor

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In this study, a new membrane reactor with a volume of 1.5 liter was made to remove nickel and cobalt. In this process, initially wastewater was entered into a settling tank. Tthe liquid phase was separated and entered into a stalactite column in order to remove suspended particles. The biosorption reaction in the reactor was studied in the presence of nanobiosorbents in different conditions of pH, biosorbent dose, and temperature and retention time. Finally, the concentration of heavy metals was investigated after the fluid had passed through the membrane system. Algae nanobiosorbent was prepared using a planetary ball mill; Scanning Electron Microscope and Brunauer-Emmert-Teller tests showed an average diameter of 95.75 nm and specific surface area of 11.25 m2g-1, respectively. Maximum biosorption efficiency equal to 93% and 91% was achieved for nickel and cobalt at pH 6, temperature 35 °C with a retention time of 80 min, at biosorbent doses of 8 and 4 g. The kinetic data fitted well by pseudo-first-order model and equilibrium data of metal ions could be described well with the Langmuir and Dubinin–Radushkevich isotherm models. The calculated thermodynamic parameters showed that metal ion biosorption is feasibile, endothermic and naturally spontaneous.

45. Espenshade, Jordan

Role and exploitation of plant-associated bacteria during phytoremediation of air pollution

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Air pollution is a major concern worldwide for the damage it causes to environmental and human health. Despite the complex composition of contaminants in the air, phytoremediation was already shown to be an effective remediation technology for indoor air quality. However, less is known for the efficiency of phytoremediation with regards to outdoors air pollution.

Plant-associated bacteria (PAB) assist plant growth and survival by providing beneficial compounds or degrading toxic substances. Similar to the benefits provided by rhizosphere and endosphere bacteria to the root, phyllosphere bacteria are also expected to play an important role since leaf and stem surfaces are known to adsorb significant amounts of pollutants. We hypothesize that communities of PAB can be manipulated and exploited to increase the potential for phytoremediation of air pollution. Therefore, bacteria were isolated from three Platanus x hispanica trees in Hasselt (Belgium), chosen based on the relative volume of nearby automobile traffic. Isolated bacteria were screened for production of compounds (acetoin, indole-3-acetic acid, and 1-aminocyclopropane-1-carboxylate deaminase) or activities (phosphate solubilization) associated with promotion of plant growth (PGP). Samples that showed positive effects in the PGP tests were screened for their tolerance to toluene (as one of the major organic air pollutants) to narrow the pool of candidate strains.

Candidate strains are tested for activities that promote resilience to environmental factors, such as UV resistance, biofilm formation, mobility, chemotaxis, and biosurfactant production. Strains with positive reactions to the most factors are identified with 16S rDNA sequences and considered for field studies.

Air pollution, hydrocarbons, phytoremediation, plant growth promotion, plant-associated bacteria

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46. Fanssi, Saloua El

Domestic wastewater treatment by constructed wetlands in mountain areas of Morocco

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Actually, more than 94 % of the populations in the Moroccan rural areas are connected to drinking water network, triggering a dramatic increase in wastewater production. Wastewater infrastructure in these regions is either poorly developed or non-existent. Most of rural areas are suffering from water pollution problems and present a high potential of illness caused by untreated wastewater discharge into the environment. In addition, these small communities have insufficient financial resources or management capacities to deal with wastewater treatment, especially when using conventional treatment systems, owing to their operational and maintenance costs and the need of qualified staff. The aim of this study is to evaluate the efficiency of a hybrid constructed wetlands (HCW) to treat rural wastewater in mountain areas of Morocco. The wastewater treatment plant was composed of three vertical-subsurface flow wetlands (VF) (130 m^2 each) working in parallel, followed by two horizontal-subsurface flow wetland (HF) connected also in parallel (88 m^2 each). The two units were planted with Phragmite australis at a density of 4plants/m2.The main removal percentages of SS, BOD5, COD, TN and TP were respectively 95, 91, 88, 63 and 63 %. In addition, the Log10 removal for total coliforms, fecal coliforms and fecal streptococci were 4.42, 4.30 and 3.91 Log unit respectively. Based on the obtained results, the hybrid constructed wetland technology is a successful method for rural region and provides good purification
performance in terms of removal of organic matter, nutrients and indicator bacteria fecal contamination, even if during arid climate.

Key words: constructed wetlands, pollutants, rural Moroccan areas, mountain

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47. Farid, Mujahid

Silicon (Si) alleviates cotton (Gossypium hirsutum L.) from zinc (Zn) toxicity stress by limiting Zn uptake and oxidative damage

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Silicon (Si) is as an important fertilizer element, which has been found effective in enhancing plant tolerance to variety of biotic and a-biotic stresses. This study investigates the Si potential to alleviate Zinc (Zn) toxicity stress in cotton (Gossypium hirsutum L.). Cotton plants were grown in hydroponics and exposed to different Zn concentration, 0, 25 and 50 µM, alone and / or in combination with 1 mM Si. Incremental Zn concentration in growth media instigated the cellular oxidative damage that was evident from elevated levels of hydrogen peroxide (H2O2), electrolyte leakage, malondialdehyde (MDA) and consequently inhibited cotton growth, biomass, chlorophyll pigments and photosynthetic process., Application of Si significantly suppressed Zn accumulation in various plant parts i.e. roots, stems and leaves and thus promoted biomass, photosynthetic, growth parameters and antioxidant enzymes activity of Zn-stressed as well unstressed plants. In addition, Si reduced the MDA and H2O2 production and electrolyte leakage suggesting its role in protecting cotton plants from Zn-toxicity induced oxidative damage. Thus, the study indicated that exogenous Si application could improve growth and development of cotton crop experiencing Zn-toxicity stress by limiting Zn bioavailability and oxidative damage.

Keywords: Antioxidant enzymes, biomass, zinc, silicon, growth

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48. Galkaduwa, Madhubhashini B.

Understanding of trace elements retention by sulfate reduction in a pilot-scale constructed wetland treatment system designed for FGD wastewater

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Generally, wastewater from flue-gas desulfurization (FGD) systems fails to comply surface water quality standards due to elevated concentrations of trace elements and other constituents. Our previous work showed that constructed wetland treatment systems (CWTSs) are effective in removing selenium from FGD wastewater, but reductive dissolution of native soil arsenic (As) is a concern. A laboratory-based soil column experiment mimicking a pilot-scale CWTS was carried out to evaluate the performance enhancement of CWTS. Main objectives of this study were to (1) examine the effect of flow rate and other soil treatments on sulfur (S) retention by CWTS, and (2) gather mechanistic information of trace elements retention in the CWTS via S and As speciation. Deoxygenated (bubbled with N2 for 10-12 min) and diluted FGD wastewater was fed to saturated soil columns bottom-up at the flow rates of X (1.42 mL/hr) and 2X with different soil treatments for 60 days and a long-term (~ 1 year) study was performed with X and 1/2 X rates. Effluents were collected continuously and analyzed for constituents of concern. End of the experiments, soils from sacrificed columns were used for bulk S and As XANES analysis. Breakthrough curves indicated enhanced S retention in soil columns with slow flow rates, indirectly implying increased reduction of sulfate in FGD wastewater. Arsenic concentration of effluents was also decreased with time. Bulk S and As XANES revealed that long submergence period and slow flow rate favored the formation of more reduced S species (S(-I), and S(-II)) and realgar (AsS), respectively. These observations indicate that modified flow rates could have a significant impact on the long-term trace elements sequestration in CWTS.

Key words: FGD wastewater, CWTS, sulfate reduction, S and As speciation

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49. Gatliff, Edward

From Phytoremediation to Hybridized Plant-Based Remediation Systems – A Summary Review, 1988 - 2015

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In 1988, several phytoremediation projects were initiated on closed agricultural chemical sites that, after many years, were successfully remediated. In 1991 the first in-situ plant-based hybridized remediation system was developed and installed to treat nitrogen and hydraulically control a nitrogen plume at a depth greater than 5 meters below ground surface. This hybrid approach emulated an engineered pump-and-treat system by utilizing trees as pumps to move water into, and through, large wells that function as treatment cells (biological and chemical) that are also enhanced by the presence of the tree. The following years realized advances in this hybridized approach that led to opportunities to apply plant-based remediation systems in challenging lithological, hydrological and remedial situations. These advances include the ability to treat and hydraulically control groundwater and/or contaminant plumes to depths of 14 meters (more is possible). Further, the approach has been refined to allow targeting of specific soil and groundwater horizons and treatment of many types organic contaminants at concentrations as high as source-level without significant phytotoxicity issues. Aspects of these plant-based hybridized systems have been patented and the terms, TreeMediation® and TreeWell®, that identify these systems have been trademarked.

The presentation will offer a summary review of the early phytoremediation projects as well as select hybridized remediation projects that have been successfully implemented over the last 28 years. Design and treatment strategies, results, and demonstration of the evolution of the hybridized technology will be highlighted.

Keywords: Phytoremediation, soil, groundwater, lithological, hydraulic control, plant-based, hybridized remediation, pump-and-treat, phytotoxicity, TreeMediation, TreeWell.

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50. Gawronski, Stanislaw

Understanding of trace elements retention by sulfate reduction in a pilot-scale constructed wetland treatment system designed for FGD wastewater

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Generally, wastewater from flue-gas desulfurization (FGD) systems fails to comply surface water quality standards due to elevated concentrations of trace elements and other constituents. Our previous work showed that constructed wetland treatment systems (CWTSs) are effective in removing selenium from FGD wastewater, but reductive dissolution of native soil arsenic (As) is a concern. A laboratory-based soil column experiment mimicking a pilot-scale CWTS was carried out to evaluate the performance enhancement of CWTS. Main objectives of this study were to (1) examine the effect of flow rate and other soil treatments on sulfur (S) retention by CWTS, and (2) gather mechanistic information of trace elements retention in the CWTS via S and As speciation. Deoxygenated (bubbled with N2 for 10-12 min) and diluted FGD wastewater was fed to saturated soil columns bottom-up at the flow rates of X (1.42 mL/hr) and 2X with different soil treatments for 60 days and a long-term (~ 1 year) study was performed with X and 1/2 X rates. Effluents were collected continuously and analyzed for constituents of concern. End of the experiments, soils from sacrificed columns were used for bulk S and As XANES analysis. Breakthrough curves indicated enhanced S retention in soil columns with slow flow rates, indirectly implying increased reduction of sulfate in FGD wastewater. Arsenic concentration of effluents was also decreased with time. Bulk S and As XANES revealed that long submergence period and slow flow rate favored the formation of more reduced S species (S(-I), and S(-II)) and realgar (AsS), respectively. These observations indicate that modified flow rates could have a significant impact on the long-term trace elements sequestration in CWTS.

Key words: FGD wastewater, CWTS, sulfate reduction, S and As speciation

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51. Gibler, Madison

Green Roofs: Benefits of Water and Energy Balance

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Green roofs use vegetation, soils, and natural processes to manage water and create healthier urban environments, providing traditional roof services and alternative stormwater management technologies. Numerous other benefits and impacts are not yet fully understood or valued. Research conducted assesses specific stormwater benefits of green roofs and analyzes potential energy benefits through side-by-side comparisons of full-scale white, traditional black rubber, and green roofs in the mid-continent Missouri climate. The 54% of stormwater retention demonstrated in this green roof research aids in urban watershed management and an observed 15 mm of storage capacity also provides an opportunity for energy dissipation. Water and energy models were combined to illustrate impacts of evapotranspiration (ET) on green roof temperatures and urban heat island mitigation. As ET is dependent on a variety of climate parameters including temperature, humidity, wind speed, and solar radiation, the potential to dissipate energy from a roof surface by means of water vaporization was modeled, with 10.9 MJ/m2 of energy dissipated for 4.8 mm of ET. The US EPA details urban temperatures 12°C warmer than rural surroundings. During daytime, the green roof displayed surface temperatures 35°C less than the black roof and 20°C less than its "cool roofs" competitor, the white roof. Models using climate data to estimate potential ET may be used as predictive tools on impacts of green roof design and can be applied in sustainable stormwater management, allowing green roofs to maximize runoff reduction, peak flow attenuation, and urban heat island mitigation, which results in economic benefits.

Keywords: green infrastructure, green roof, stormwater management, energy, sustainability

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52. Gonzalez-Chavez, Ma del Carmen A.

Arsenic concentration in wild plants from natural attenuation islands on two mine tailings

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Arsenic accumulation in wild plants naturally established in the contaminated area of Zimapan, Hidalgo, Mexico was studied. Total and EDTA-extractable As concentrations in the rhizosphere, in plants (shoots and roots) and deposition on leaves of eleven plants growing on two mine tailings (Santa Maria and San Francisco) were analyzed. Total soil As concentration ranged 4016 to 17,178 mg kg-1 while EDTA-extractable As was from 234 to 499 mg kg-1 for San Francisco and Santa Maria sites, respectively. The prevalent vegetation was: Vigueria dentata, Brickellia veronicifolia, Ruta graveolens, Dichondra argentea, Cuphea lanceolata and Aster gymnocephalus. As these plants may be collected from these polluted sites because of their use as traditional remedy of several illnesses, they represent a potential risk and pathway of entrance to human body. Similarly, some of these plants can be eaten by domestic animals living nearby the mine tailings. As shoot concentrations are higher than the maximum level tolerated by these animals (50 mg kg-1). A. gymnocephallus had the highest As shoot concentration (2,409 mg kg-1), bioconcentration (8.6) and translocation factors (9.6), and deposition of As in aerial part (7,521 mg kg-1). These values were independent of the soil As concentrations. In contrast, Dalea bicolor presented the lowest As shoot concentrations (52-88 mg kg-1) at San Francisco and Sta. Maria, respectively). Results also highlight that these plants functioning as As phytotraps as they are retaining high As concentrations on leaves surface. Hence, they strongly influence As dispersion and risk in mine tailings.

Keywords: As accumulation, translocation factors, As tolerant plants.

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52. Greipsson, Sigurdur

Chemically induced phytoextraction of lead (Pb) contaminated soil by high biomass producing grasses

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Phytoextraction of lead (Pb) contaminated soil using high biomass producing grasses that can potentially be used in bio-fuel production has recently been emphasized. Chemically induced phytoextraction of Pb contaminated soil by high biomass grasses has involved manipulation of the soil by EDTA, citric acid and iron (Fe) applications. Also, manipulations have involved suppression of symbiotic arbuscular mycorrhizal fungi (AMF) by using soil fungicide (benomyl). In addition, foliar application of chemicals to enhance plant growth and metal uptake have involved phytohormones and nitric oxide (NO). Soil application of citric acid was found to be effective in maintaining soil pH at 4.5 and producing shoot Pb concentrations no different than those of plants treated with EDTA alone. Iron supplement to roots of corn (Zea mays) in combination with EDTA increased Pb translocation (from root to shoot) significantly. Suppressing AMF activity through benomyl application resulted in more than 500% increase in Fe concentration in foliage of plants compared to Control plants. This strongly indicates that AMF is actively involved in Fe uptake by plants. The phytohormone benzylaminopurine (BAP) (1.0 µM) generated a 48% increase in dry mass of foliage of switchgrass (Panicum virgatum) compared to Control plants. Application of BAP was found to significantly increase root Pb concentration when combined with EDTA, citric acid, and benomyl. Foliar application of the NO donor S-Nitroso-N-acetyl-DL-penacillamine (SNAP) (1.0 µM) was found to significantly increase dry mass of foliage of switchgrass. A pilot field study of chemical phoytoextraction of Pb contaminated soil using switchgrass is in progress.

Keywords: arbuscular mycorrhizal fungi, citric acid, phytohormone, lead, nitric oxide

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53. Gu, Hai-Hong

Effects of Fly Ash and Steel Slag on Trace Metal Accumulation in Rice Seedlings Planted on Trace Metal Contaminated Acidic soil

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The effects of silicon rich amendments, fly ash and steel slag, on pH values and the phytoavailability of cadmium, lead, copper and zinc in a multi-metal contaminated acidic soil and metal accumulation and silicon nutrient in rice seedlings were investigated by a pot experiment in this study. The results indicated that the addition of fly ash (20 and 40 g·kg-1) and steel slag (3 and 6 g·kg-1) significantly increased soil pH values from 3.9-4.0 to 5.0-6.5, and markedly decreased the phytoavailability of Cd, Pb, Cu and Zn by at least 58%, 80%, 75% and 75%, respectively. The application of fly ash and steel slag increased silicon concentration and suppressed metal accumulation in rice seedlings, in particular for Cd and Pb accumulation. Moreover, it was found that translocation of Cd and Pb from root to shoot was dramatically restrained by adding amendments, which might due to the formation of trace metal silicate precipitation in roots. These results demonstrated that fly ash and steel slag could be effective in improving soil environment and alleviating trace metal accumulation in rice seedlings grown on trace metal contaminated acidic soils, and steel slag was more efficient than fly ash.

Keywords: Acidic soil, trace metals, silicon rich amendments, alleviation effects, rice seedlings

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54. Hadi, Fazal

Phytoextraction of Cadmium with increasing concentration of total phenolics and free proline in Veronica anagallis aquatica and Epilobium laxum plants

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Plants have the natural ability to absorb and concentrate essential elements in its tissues from water solution and this ability of plants can be exploited to remove heavy metals from the contaminated water. For this purpose two plants Veronica anagallis aquatica and Epilobium laxum hydroponically studied. In this study the effect of different NPK fertilizers and plant hormones (GA3 and IAA) were evaluated on growth, biomass, Cd accumulation, free proline, phenolics and chlorophyll contents in the plants grown in Cd contaminated growth media. Results of the experiment showed that in both plant NPK addition to media (treatment T4) produced the highest significant increase in growth, biomass (fresh and dry), cadmium concentration, proline, phenolics and chlorophyll (a and b) concentrations. Significant effect of GA3 in combination with NPK foliar spray (treatment T12) was also observed on most of the growth parameters, Cd concentration and proline and phenolics contents of the plants. The proline and phenolics showed strong correlation with the cadmium concentration within plant tissues. The proline also showed as strong positive correlation with phenolic contents of root and stem. Veronica plant was found to be a hyperaccumulator of cadmium because it showed bioconcentration factor much higher than one (1) while the Epilobium plant is not hyperaccumulator of cadmium metal. It is recommended for further study to investigate the role of Veronica plant for other metals and also study the functions of phenolics and proline contents in heavy metals phytoextraction by various hyperaccumulator plants species.

Keywords: Cadmium, fertilizers, growth regulators, proline, phenolics, chlorophyll

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55. Hadi, Fazal

The Role of Iron in Cadmium Phytoextraction and Production of Endogenous free Proline and total Phenolics in Ricinus communis under hydroponic condition

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Hydroponic experiment was performed using different concentrations (2.5, 5 and 7.5 ppm) of Fe foliar spray and added into growth media. Effect of Fe was evaluated on cadmium phytoextraction, total phenolics, free proline and chlorophyll contents in Ricinus communis grown in Cd contaminated (10 mg/L) media. Results showed that addition of Fe into media at highest concentration (7.5 ppm) most significantly increased roots and stem dry biomass while lowest (2.5 ppm) Fe concentration demonstrated highest dry biomass (DBM) in leaves. Higher concentration (7.5 mg/L) of Fe foliar spray most significantly increased Cd contents in different parts of the plant i.e. root (228.67 ± 6.11 ppm), stem (97.80 ± 3.75 ppm) and leaves (162.33 ± 11.24 ppm). Free proline were found highest in roots (67.00 ± 2.00 ppm) and leaves (41.88 ± 3.56 ppm) of plants treated with 2.5 % Fe (media addition) and 2.5 % Fe (foliar spray) respectively. Foliar spray of 7.5 mg/L) and 2.5 mg/L of Fe showed highest total phenolics in roots (82.67 ± 2.52 ppm) and leaves (171.00 ± 4.98 ppm) respectively. Cadmium accumulation in roots showed negative correlation with roots DBM. Proline and phenolics demonstrated positive correlations with Cd accumulation in plant tissues. Significantly positive correlation was found between total phenolics and Cd contents in roots (R2 = 0.70) and leaves (R2 = 0.60). Fe foliar spray application was found superior then Fe addition to media. Further investigation is suggested to study the effect of Fe foliar spray on Cd phytoextraction using different plants species.

Keywords: cadmium, phenolics, proline, Ricinus communis

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56. Hajabbasi, Mohammed A.

Phytoremediation of soil contaminated with petroleum hydrocarbon using different amendments

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Increasing industrial and urban areas in the developing countries is diminishing the vital resources like soil and water. Adding amendments such as organic carbon and clay minerals help soil for better and faster remediation. In this study, the use of low-cost and environmentally safe amendments for the in situ remediation of hydrocarbons is investigated. A polluted soil (from Isfahan refinery complex) was treated with three soil amendments (natural bentonite, cationic surfactant modified bentonite and activated carbon) and incubated at two rates of 40 and 80 g/kg for 50 days. After the incubation period, the hydrocarbon concentrations were extracted and gravimetrically determined and corn (Zea mays) was grown in pots and the yield indices were determined. The results showed that amendments significantly decreased the amount of extractable soil hydrocarbons accompanied by increased plant yield. Activated carbon showed the most effectiveness on reducing the pollutant concentrations and reduced the soil hydrocarbon content from 5% in the polluted soil to 3.7% in the activated carbon-amended soil. All amendments applied at 40 g/kg rate were as effective as the amendments applied at 80g/kg rate. The effects of these amendments on reducing hydrocarbon in soil were also confirmed by greater yield compared to the untreated soil.

Key words: clay minerals, cation modification, activated carbon, adsorption, hydrocarbon.

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57. Hettiarchchi, Ganga M.

Gardening on contaminated urban soils: Mechanisms to reduce risk potential

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Lead (Pb), arsenic (As) and polycyclic aromatic hydrocarbons (PAHs) are among the most common contaminants in urban soils. Gardening in contaminated soils can result in contaminant transfer from soil to humans through vegetable consumption and unintentional direct soil ingestion. Field experiments were conducted in several urban community gardens with soil total Pb concentrations of 60 to 513 mg kg-1, total As concentrations of 23 to 146 mg kg-1 and/or total PAHs concentration of 50 mg kg-1. The objectives of this project were to evaluate soil-plant transfer of contaminants, the effects of incorporation of composts as a means of reducing contaminant concentrations in vegetables and the bioaccessibility of soil Pb and As, and the effects of vegetable cleaning techniques on the Pb and As concentrations in the edible portions of vegetables. Results indicated that the pathway from contaminated soil to plant to human is insignificant. In general, concentrations of Pb, As and PAHs in vegetables harvested at test sites were either low or non-detectable and contaminants can be further diluted by the addition of compost. Bioaccessible Pb or As in the compost-added soils was less than that of the no-compost soils; compost addition reduced the potential of transferring soil contaminants to humans via vegetable consumption and direct soil ingestion. Thorough cleaning of vegetables further reduced the potential of transferring soil contaminants to humans. Roots tend to accumulate Pb. If in doubt regarding potential soil contaminants and their respective concentrations growing root crops should be avoided.

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58. Honeker, Linnea

Plant root-microbe community dynamics during the phytostabilization of metalliferous mine tailings in semiarid regions

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Phytostabilization of legacy mine tailings in semiarid regions is an effective method for containment of metal contaminants on site, however, sustainable plant establishment can be challenging due to the harsh mine tailing environment with low pH, low nutrients, and high metal concentrations. Rhizosphere bacterial communities perform important beneficial services to promote plant health such as increasing nutrient availability and out-competing pathogens; services which may be essential in the harsh mine tailings. We hypothesize that a characterization of rhizosphere-associated bacterial communities of Buffalograss (Buchloe dactyloides) during phytostabilization will define specific microbial dynamics associated with successful plant establishment in metalliferous mine tailings. 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. This research assesses the rhizosphere-associated microbial communities of Buffalograss of varying degrees of plant health (chlorophyll and plant cover) from a phytostabilization field study at IKMHSS exposed to varying environmental (pH, total organic carbon [TOC], and total nitrogen [TN]) conditions. Bacterial communities on the root surface and rhizosphere-associated soils were characterized using fluorescence in situ hybridization (FISH) and 16S rRNA iTag sequencing, respectively. pH and TOC were found to correlate strongly with bacterial communities from root surfaces and the rhizosphere. Plant cover and chlorophyll levels, indicative of plant health and establishment, correlated with several bacterial populations, including Gammaproteobacteria, Firmicutes and Proteobacteria. Increasing our understanding of the rhizosphere microbial dynamics of plants grown in mine tailings can help maximize plant establishment and sustainability during phytostabilization.

Keywords: phytostabilization, mine tailings, plant associated microorganisms

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59. Huang, Guoyong

Enhanced efficiency of Cu removal by castor (Ricinus Communis L.) in the presence of exogenous low weight organic acids

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Phytoremediation of heavy metal polluting soil is one of the most important technologies to remove the soil contaminants. Castor (Ricinus communis L.) is a hyperaccumulator newly discovered in an abandoned land of Cu mine. With the advantages of high ability to accumulate Cu, great biomass and high economic values, castor is a potential candidate for the remediation of Cu polluted soils. The aim of this study was to clarify Cu tolerance threshold of castor and to explore the effect of exogenous low weight organic acids on Cu uptake and abiotic metal stress damage in castor. A hydroponic experiment was carried out in the phytotron (25, 14h day/10h night)with elevated Cu levels (0, 4, 8,16, 24 mg/L), citric (2, 6mmol/L) and tartaric acid (3, 9mmol/L) in nutrition solution.After two weeks, the cultivated castors were harvested. The contents of ASA, MDA, GSH, SOD, and soluble protein in fresh leaves was determined. The sampled castors were dried in the oven at 60 and Cu contents in the leaves, stems, and roots of castor were analyzed. As a Cu tolerance plant, castor accumulated more Cu in root tissue than that in shoot tissue in order to help plant survive Cu toxicity. The high Cu and the presence of organic acids effected the plant biomass, synthesis of GSH and protein, antioxidative enzyme activities (SOD), the contents of ASA, and lipid peroxidation. In conclusion, citric and tartaric acids acted as a ligand to chelate with Cu and entered in the form of organic acid-Cu chelation, which efficiently alleviated the physiological toxicity from free metal ions.

Keywords: phytoremediation; copper removal; antioxidant enzyme; organic acids

This work was supported by the National Natural Science Foundation of China (No. 41371470)

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60. Hutchinson, Stacy

Integrating the Landscape: A Unified Watershed Management Program

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Non-point source pollution from agricultural and urban land uses is the leading cause of surface water degradation, and, while the BMP technologies to combat this issue have been developed, implementation at meaningful watershed-scales lags. Among the factors constraining such impactful implementation are a lack of watershed management programs that integrate watershed stakeholders across sociopolitical bounds and a lack of sustainable funding mechanisms to support such programs. As regulatory pressure to meet mandated water quality targets (e.g., TMDLs) continues to increase, the challenge to produce water quality programs that are environmentally and cost effective must be met. In order to address this issue, a pilot-scale water quality market program between the City of Wichita's regulated stormwater system and upstream agricultural producers in the Little Arkansas Watershed is being developed. Based on dialogue between stakeholders representing the watershed's agricultural (represented by the Little Ark Watershed Restoration And Protection Strategy program) and urban (represented by the City of Wichita's Stormwater Advisory Board and City officials) communities and the Kansas Department of Health and Environment, which administers TMDLs and water quality permits, the program works to optimize the placement of BMPs within the watershed for maximum water quality and quantity benefit of the integrated system. This program will serve as a model for communities nationwide.

Keywords: watershed management, BMP, integrated system, water quality

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61. Huynh, Khang

Metabolism of Triclocarban by Hydroponically Grown Pepper Plants (Capsicum annuum)

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Plant accumulation and metabolism of emerging organic contaminants, such as personal care products, has been a growing concern over the past few years due to potential hazards to human health. In many cases, biotransformation products of these contaminants may impose more toxicity than parent molecules, leading to the necessity of studies regarding phytometabolism. In this study, Jalapeno pepper plants were grown in hydroponic media containing both radioactive labeled 14C- and nonlabeled-triclocarban in order to track the potential metabolic pathways of triclocarban following plant uptake with time. Our preliminary results indicated that triclocarban was predominantly present as metabolized forms that were non-extractable by organic solvents (e.g. up to 90.1% in stem samples). After 12 weeks, triclocarban proportion detected in cellulose compartments of roots, stems, leaves and fruits were 30.9 ± 4.2, 7.6 ± 1.0, 5.2 ± 1.5 and 1.0 ± 0.5 %, respectively. Likewise, the corresponding percentage for non-cellulose fractions were 37.9 ± 4.1, 1.3 ± 0.2, 3.8 ± 0.9 and 1.3 ± 0.3%, respectively. This observation demonstrated that triclocarban was largely metabolized after being taken up by plants, and eventually sequestered into the cell wall. The fact that most of the studies regarding plant uptake and accumulation of xenobiotics have overlooked the metabolized products might result in underestimating the potential threats imposed on human health via food chains. Presently, we are working on interpreting mass spectra data to determine the metabolites of triclocarban in different plant tissues and during the growing period.

Keywords: antimicrobials, vegetables, antibiotics, phytometabolism, conjugation, transformation

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62. Iram, Shazia

Development of an Effective Phytoremedial Technology for Metal Contaminated Calcareous Soils

Phytotechnology for Contaminate Reduction and Habitat Creation:
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In present study peri-urban agricultural areas of Punjab, Pakistan were selected. Soil samples irrigated with municipal and industrial wastewater were collected from two depths 0-15 and 15-30". These soil samples; wastewater and crops/ vegetable samples collected from study areas were analyzed for heavy metals contamination. Soil micro fungi were also isolated by standard methods. Copper, lead, cadmium and Chromium were accumulated more than recommended permissible limits in the studied areas. Natural, biological and chemically enhanced phytoextraction potentials of maize (Zea mays L.) and mustard (Brassica campstrus) were explored by growing them on two contaminated soils of for 75 days. Soils were amended with varying amounts of DTPA at 0, 1.25, 2.5, and 5.0 mM kg−1 soil and inoculums of three fungal species (Aspergillus niger, Aspergillus fumigatus and Aspergillus flavus) to enhance metal solubility and availability. In pot experiment under green house, addition of fungi and DTPA significantly increased the Cu, Pb, Cr and Cd concentrations in roots and shoots and also increased uptake, Bioconcentration factor, Phytoextraction rate and Extraction efficiency over the control. Overall A. fumigates presented good results in increasing biomass production of maize and mustard plant in both Gujranwala and Lahore soils. Post harvest metals contents in soil were analyzed and A. flavus and A. fumigates showed better behavior in making metals available by their solubilizing efficiency. A phytoremediation model was developed based on generic data for the reclamation the metals contaminated calcareous soils of Punjab.

Keywords: soil, Maize, Mustard, Chelate, Fungi, Phytoremediation

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63. Jamil, Muhammed

Bioremediation of hydrocarbon contaminated soil

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Extensive hydrocarbons exploration activities may result in the contamination of all compartments of the environment. Scientists are looking for possible ways to remediate these contaminants. Various physical and chemical methods are being used from past decades. Nowadays, the process of bioremediation is considered for removing these pollutants from contaminated sites. It is cost effective and efficient than other techniques. The purpose of the present research was to isolate and characterize hydrocarbons degrading bacteria from oil contaminated soil samples collected from Mamikhel-1 oil field (Pakistan). The samples were microbiologically analyzed using standard microbiological methods. Through enrichment culturing technique pure bacterial cultures were obtained. Isolated pure cultures were differentiated by various morphological and biochemical characteristics. Finally on the basis of these tests, the bacterial isolates were identified to belong to the genera as follows: Escherichia, Citrobacter, Pseudomonas, Bacillus, Nessiria, and Staphylococcus. The 16S RNA gene of these isolates was also amplified for molecular characterization. These organisms were further studied to determine their biodegradation activities on various hydrocarbons as the sole carbon source using (BH) medium. It was observed that these bacteria can break down Benzene, Toluene, Xylene, Naphthalene and n-hexane. Pseudomonas sp. was the most dominant bacterial genus and the most dominant degrader. The ability of these isolates to degrade hydrocarbons is clear evidence that their genome contains the hydrocarbon degrading gene. The resistance of bacterial isolates against heavy metals (Zn, Fe, Pb, Hg and Co) was also evaluated. Amongst the tested heavy metals Fe and Zn were the most tolerated by the tested isolates. The most metal tolerant strains were Escherichia sp. Citrobacter sp. and Pseudomonas sp.

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64. Just, Craig

Modeling Sustainable Reuse of Nitrogen-laden Process Water by Poplar

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The objective of this research was to numerically model the fate and transport of nitrogen in poplar and grass irrigated with food processing wastewater under the current practice and under proposed scenarios. A simulated field-scale trial for poplar and grass showed that for a nitrogen loading of 540 kg ha-1 more nitrogen was uptaken and denitrified in poplar compared to grass. No nitrogen was lost to groundwater for poplar while 93 kg ha-1 was lost to groundwater with grass. Using a 1,540 kg ha-1 nitrogen loading for poplar, and assuming a weekly, daily and "calculated" irrigation schedule during the growing season, the simulation showed N uptake of 1,453 kg ha-1, 1,415 kg ha-1, and 1,443 kg ha-1, respectively. More N was lost to groundwater for the weekly (17 kg ha-1), versus the daily (6 kg ha-1), versus the calculated (4 kg ha-1) irrigation scheme. The best case scenario assumed a fixed land area of approximately 1,000 ha with fully grown poplars, 757 Ml of process water storage and a "diverse" irrigation scheme. The simulation for N applied, N uptaken, N denitrified and N loss to groundwater was 951 kg ha-1, 882 kg ha-1, 51 kg ha-1, and 15 kg ha-1, respectively.

Keywords: HYDRUS 1D, poplar, sustainable water reuse, nitrogen management

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65. Kanso, Ali

Early Stage of Technosols Evolution in Response to Organic Amendments

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LORVER project, supported by Lorraine Region and European Union, aims to create industrial chains for plant biomass production from derelict lands and industrial by-products. In this work, phytoextraction was used as a sustainable restoration technology allowing metals recovery from constructed Technosols.

A Biocentre® treated soil was spiked with trace elements by additions of industrial sludges (BTS, 5% DW) and then amended with biochar (B2TS, 3% DW) or compost (BTSC, 3% DW). A three months greenhouse experiment was performed with planted (Noccaea caerulescens and Alyssum murale) and unplanted soils. The soil solution composition was modeled using Phreeqc. Soil physicochemical parameters, Fe-Mn oxides, metal pools, (Co(NH4)6-exchangeable, DTPA-extractable and bound on Fe-Mn oxides) and plant growth were investigated.

Both amendments improved plant root development and metal extraction. Soil cationic exchange capacity increased over time while exchangeable metal pools decreased significantly (80 to 100%). In unplanted soils, the DTPA-extractable pool of Cd and Ni kept constant over time whereas that of Zn increased in BTS and BTSC. N. caerulescens and A. murale respectively strongly decreased Cd-Zn and Ni DTPA pools. Phreeqc highlighted, in solution, a decrease of free metal concentrations in both amended soils. Principal component analysis revealed three distinct groups corresponding to the three studied Technosols. This showed a fast and specific evolution of soil properties according to amendments.

Supplying Technosols with biochar or compost lead to different speciation of metals whereas plant cover did not affect the early stage of their evolution. Both amendments appeared relevant to improve phytoextraction from abandoned industrial materials.

Keywords: Traces metals, Compost, Biochar, Technosol, hyperaccumulators plants

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66. Kaur, Satinder

Volatile Organic Compounds Prevalence and their Removal in Indoors of Mumbai City

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Recently through many researches, it has been proved that the plants have capability to remove pollutants from indoor air. Number of authors such as Wolverton, 1989; Wood et al., 2000; Tarran et al., 2002; Orwell et al., 2004 have reported that potted plants can remove VOCs from indoor air at different rates . Using plants to remove pollutants is an attractive and cost effective way to improve indoor air quality. Several indoor species have been screened for their ability to remove VOCs such as benzene, toluene, TCE, m-xylene, hexane etc. Indoor plants which have been commonly used for the removal of VOCs are Hedera helix, Chlorophytum comosum, Epipiremnum aureum, Spathiphyllum, Aglaonema modestum, Chamaedorea sefritzii, Sansevieria trifasciata, Philodendron scandens, Philodendron selloum, Philodendron domesticum, Dracaena marginata, Dracaena fragrans, Dracaena deremensis, Ficus benjamina. The efficiency of VOC removal varies substantially among species. To date, only a limited number of indoor species have been tested for their removal efficiency and the range of pollutants assessed is even more limited. It is evident that a better understanding of the removal efficiency of a diverse range of indoor plants is needed. The present study aims at assessing and quantifying the prevalence of various VOCs in indoors of many household in Mumbai city, India. Based on the prevalence, experiments have been conducted to assess the ability of locally prevalent plants such as to remove VOCs from indoor air. Tests were conducted in a plexiglas chamber. Removal efficiencies have been obtained at various levels of VOCs concentrations. The resultant chamber concentrations were measured after every 6hrs for 24 hrs. Locally available plants ie. Tradescantia spatheca, Fittonia verschafeltii, Tradescantia selections, Sanseveira parva, Sanseveira cylindrical were used. The study makes an attempt to assess the efficiency of plants for VOCs removal.

Keywords: indoor air quality, volatile organic compounds, pollutants, plants

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67. Kennen, Kate

Integrating Phytotechnology and Landscape Design

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Typically, phytotechnology plantings are employed post-site contamination to help clean up already contaminated environments by taking advantage of the positive effects that plants can have upon harmful toxins and chemicals. 'PHYTO: A Resource for Site Remediation and Landscape Design' is a book (recently written by Kennen & Kirkwood and published by Routledge in Spring 2015) that explores the creation of projective planting designs with preventative phytotechnology abilities, 'phytobuffering' where future pollution may be expected for particular site programs. This presentation will highlight the planting types and site strategies developed for the book including the environmental, spatial, cultural and aesthetic qualities of the productive vegetation considered. Recommendations for performative plantings and site design will be summarized using illustrative graphics and diagrams.

This presentation will cover the 18 different phytotypologies developed (phytotechnology planting types), from Degradation Hedges to Multi-Mechanism Mats, and will highlight opportunities for application on 16 different site programs (i.e. gas stations, road corridors, railway beds etc.) Aesthetic composition and consideration of natural and cultural systems are integrated with the potential phytotechnology role of plants to assist landscape architects, engineers and site owners. 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

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68. Krabbe, Stephen

Suppression of Prairie Grasses Due to Excess Magnesium in a Portion of a Restored Prairie at the DOE Weldon Spring Site

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In June 2002, the Department of Energy (DOE) began establishing the 150 acre Howell Prairie around the disposal cell at the DOE Weldon Spring Site (WSS). The majority of the prairie was established by regrading existing soil. The exception is one area where the clay base is different from the other soil across the prairie (subarea 2C). Vegetation sampling was conducted on four permanent plots across the prairie beginning in 2008. Vegetation analysis shows that three of the four plots show strong establishment of native prairie species including prairie grasses. The fourth plot (subarea 2C), where the soil is different, shows significantly less native grass cover and stunted vegetation compared to the three plots established on native soil. 123 soil samples were taken in 7 different months in 6 different years across the entire prairie restoration area. Across the prairie, N, P, K and Mg were not limiting. pH was slightly high for a prairie, OM was slightly low and CEC was similar across the prairie. Ordination of Mg/K shows that Mg is very high in subarea 2C. Excess Mg has been demonstrated to suppress growth of prairie grasses. Subarea 2C contains kaolinite-smectite clay which is high in Mg. Weathering of the clay will release Mg indefinitely. An inexpensive, nondestructive treatment (addition of K) could be applied to remediate this area. Native grasses and forbs are present in subarea 2C, so expensive reseeding should not be necessary.

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69. Kumar, Pawan

The influence of Cu or Zn nutritional status on the uptake of CuO or ZnO nanoparticles by plants

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The advancement of nanotechnology and the great potential of using nanomaterials and nanodevices has opened up novel ways of transforming agriculture and food production. Nanoparticle based fertilizers can save fertilizer consumption by providing a more controlled and efficient release of micronutrients. Micronutrient deficiency is one of the most serious problems in plant and human nutrition and has attracted global attention. The aim of this research is to determine if plants with a micronutrient deficiency make use of the engineered nanoparticles (ENPs) as a nanofertilizer. This research has two main objectives: 1) Determine the effect of plant's nutritional status on the uptake of ENPs. 2) Examine the effect of plant's nutritional status on the behavior of ENPs in aqueous suspensions.

Hydroponically grown carrot plants were grown under different Cu or Zn micronutrient regimes for a specific period of time and thereafter exposed to corresponding ENPs (CuO or ZnO) for a short period of time. Electron microscopy is being used with the harvested plant tissues to detect the presence of ENPs and the metal concentration is being determined by elemental analysis. Dissolution studies were also performed on the residual hydroponic solution to determine whether the plants grown under different micronutrient regimes influenced the dissolution of the ENPs. The results from this research are expected to make a contribution to the ongoing efforts of the scientific community to use the nanotechnology enabled methods for sustainable agriculture.

Keywords: nanoparticles, nanofertilizer, micronutrient, dissolution, hydroponics

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70. Learnmore, Kambizi

Heavy metal content of Gunera perpensa, a medicinal plant used in the Eastern Cape South Africa

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Trace metals in G. perpensa an aquatic medicinal plant commonly available in South Africa, Eastern Cape province has been quantitatively analyzed using Atomic Absorption spectrophotometer. Medicinal plants were disinfected with 0.1% $HgCl_2$ and digested with 95% H_2SO_4 and 35% H_2O_2. Six heavy metals (Fe, Cu, Mn, Pb, Ni, Zn) were chosen on the basis of their effects on human health. From the results of the study, all six heavy metals were present in the sample plant material, except that Pb was not detected. The highest level of Fe was observed in fresh material of G. perpensa at 1.12±0.003 ppm whilst the lowest level was found in the sample that was stored for more than 60 days at 1.00±0.01 ppm. The concentrations of Mn, Pb, Ni and Zn were all less than 1.5 ppm and the lead concentration in the water extract was found to be high at 5.74±0.110 ppm but still falls below permissible limit of 10 ppm. The concentration of Cu was found in G. perpensa at 1.24±0.002 ppm. Despite the fact that this plant grows in low lying areas with high content of industrial effluent, the findings generally suggest that the use of this plant species for controlling diseases will not cause heavy metal toxicity and can be of good use to the users in cases of micronutrient deficiency.

Key words: Medicinal plants, heavy metals, spectrophotometer

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71. Lei, Mei

Assessment of Phytoremediation Application in China: costs and benefits

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The Chinese government puts great efforts on soil remediation, since nearly 19.4% of investigated farmland sites are contaminated by arsenic and heavy metals. Phytoremediation has received increasing attention for soil remediation. However, recently, it has been questioned whether phytoremediation is really cost effective, due to the lack of a thorough economic analysis of phytoremediation technology. We have investigated the top 10 phytoremediation projects of heavy metals contaminated soil in China. The area is from 1 ha to 138 ha distributing in different provinces, with varied natural and economic conditions. Essential experiences of the application of phytoremediation technologies would be reported. In addition, based on these projects, the economic knowledge of phytoremediation would be integrated. Without company participation, Costs for the phytoremediation include basic investment and daily operating cost, with basic investment consisting of pollution investigation, remediation strategy establishment, land preparation, seedlings equipment, irrigation equipment, incineration equipment, etc., while the daily operating cost consisting of manpower, purchase of fertilizer, compensation to farmers, etc. Benefits include direct benefit and indirect benefit, with the direct benefit mainly coming from the products of economic crops, whereas the indirect benefit consisting of environmental benefit and social benefit. Results can provide valuable experiences for the related scientists, engineers and the decision makers.

Keywords: Application, benefits, costs, heavy metal, phytoremediation

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73. Licht, Louis

Phyto Processes for PCB Removal in Lagoon and Riverine Sediments

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This report summarizes the forthcoming research and demonstration using phytoremediation (Phyto) techniques for removing Polychlorinated Biphenyl (PCB) from sediments at the Altavista Virginia six-acre waste water Lagoon Site. PCB concentrations as high as 50,000 ppm have been measured in sediments deposited over 30 years ago. The Virginia Department of Environmental Quality has established a 50 ppm total PCB cleanup concentration goal. Research at The University of Iowa has proven that a grass rhizosphere accelerates the PCB mineralization rate in planted soils 15 cm deep. The poplar and willow root systems grow predictably deeper at full-scale than grass alone. It is proposed that ECap® tree covers will help contain PCBs in the subsurface by keeping the surface soil layer intact while sustaining microflora intimate with roots. Six ECap® plots were installed at the Site between 2012 – 2014. Plots occupy 2,000 m2 built into the lagoon by placing a layer of soil blended using local materials over sediment. Unrooted poplar whips were pushed through the soil and sediment layers to the top of the clay liner. Poplar and willow roots now expand through the entire sediment and cover layer - growing a healthy plant rhizosphere in three feet of sediment within an operating lagoon. The planted poplar and willow trees growing in the cover soil and sediment increase water transpiration from sediment. During the growing season, flooding and drying within the lagoon sediment pulse the water content, oscillating the redox potential in a more diverse microbe population. In June 2015, an on-site meeting of scientists, engineers, academic researchers, town staff and regulators will review the past phyto demonstration and on-going PCB removal research using various techniques. Results from this meeting will be summarized as part of this presentation.

Keywords: PCB, sediment, rhizosphere, phytoremediation, poplar, willow

74. Licht, Louis

Modeling Leachate Irrigation on Landfill ETCap® to Manage Water by Poplar and Willow

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The objective of this numerical model is to estimate water percolation through different landfill covers at 4 locations across the U.S. This model shows that percolation of normal precipitation through no grass or grass covers is reduced under irrigated poplar with 1 meter deep roots. The transpiration is increased by a tall poplar on top of a windy landfill. In the upper U.S. Midwest climate, the grass/precipitation percolation is equivalenty matched by irrigating approximately 3 million liters/hectare (330,000 gallons/acre). For five operating ETCapped landfills, leachate irrigated back on top the interim cover fills four objectives:

1. Recycles water back onto the landfill cover rather than hauling to a wastewater treatment plant – saving hauling and disposal cost
2. Due to growing plants and reduced hauling energy, this leachate irrigation greatly improves carbon cycling rather than creating significant carbon emission
3. The system operates year-round to reduce leachate hauling liability cost.
4. Water that does percolate back into the landfill improves the rate of waste decomposition by leachate recirculation. Since the first operating ETCap, 138 million liters (37 million gallons) of landfill leachate has been recirculated back onto landfill covers.

Keywords: HYDRUS 1D, poplar, leachate management, sustainable landfill closure,
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75. Limmer, Matt

The Influence of Tree Properties on Contaminant Concentrations at Field Sites

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In phytoscreening and phytoremediation of organic contaminants, the effect of tree properties has been long debated. In phytoscreening, differences between tree genera can reduce accuracy resulting from differences in tree response to subsurface contamination. In phytoremediation, differences in contaminant uptake between tree genera affect system efficacy. Here, we report on volatile organic compound (VOC) concentrations measured in approximately 2,000 trees at 39 contaminated sites. Tree samples were taken via traditional tree coring and analyzed using in vitro solid-phase microextraction (SPME). The accuracy of the analytical approach was assessed by examining the potential for competitive sorption between target analytes and other VOCs present in wood. Contaminants measured in trees at field sites included several chlorinated solvents and aromatic hydrocarbons such as benzene. The effects of tree diameter, tree genus and wood type on tree contaminant concentrations were assessed. Of the contaminants encountered, only perchloroethylene (PCE) was significantly affected by these tree properties. However, the importance of these effects was small, as a regression model built upon these effects explained little variance in tree PCE concentrations (adjusted $R2 = 0.031$). However, contaminant properties were correlated with contaminant concentrations measured in trees. Quantile regression demonstrated that 90th quantile tree VOC concentrations were significantly reduced by increased hydrophobicity and increased Henry's constant. These findings suggest that subsurface contaminant concentrations dominate tree contaminant concentrations, regardless of tree properties such as diameter, wood type and tree genus.

Keywords: Phytoscreening, Chlorinated solvents, SPME

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76. Limmer, Matt

Estimation of Benzene, Toluene and Chlorobenzene Removal Rates by a Phytoremediation Plot

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A phytoremediation plot was studied to model its removal of benzene, toluene and chlorobenzene. To assess overall removal rates, groundwater contaminant concentrations were extensively measured. Rhizodegradation was assessed through soil mesocosms and through testing for the presence of dioxygenase genes. Tree contaminant removal was estimated through measurement of tree leaf area and estimates of transpiration. A comparison of the phytoremediation removal rate with estimates of onsite contaminant mass was used to estimate cleanup time frames.

Overall, the investigation indicated that substantial microbial degradation was occurring in the subsurface. Estimates of transpiration indicated that the plot was removing approximately 240,000 L of water per year. This quantity of water removal implies substantial removal of contaminant due to the high levels of contaminants in the groundwater. However, these contaminants extensively sorb to the soil, resulting in large quantities of contaminant mass in the subsurface. The total estimate of subsurface contaminant mass is also complicated by the presence of NAPL, an additional contaminant mass which is difficult to quantify. These uncertainties result in large uncertainty in the cleanup timeframe, although mean estimates are on the order of decades. Collectively, the model indicates substantial contaminant removal is occurring, although the large quantity of contaminant mass onsite slows the cleanup timeframe.

Keywords: Phytoremediation performance, Rhizodegradation, Phytovolatilization

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77. Liphadzi, Stanley

Use of indigenous plants as key components of the ecological infrastructure to secure water and food in South Africa

Liphadzi Stanley* and Naidoo Shane

South Africa's water ecosystems are under increasing pressure, with impacts such as pollution, regulation of flow by impoundments, over-extraction of water, and the breakdown of natural bio-geographical barriers. These degradations affect condition and functioning of these freshwater ecological systems and thus the ecological services that they provide to poor communities that depend on them. Wetlands have been subject to widespread degradation with an estimated 50% of South Africa's wetlands having been destroyed or converted. While Ecological Reserve determination, resource classification and resource quality objectives are legislative tools developed to reverse or prevent these impacts, the implementation of these tools is still in the early stages, with costly implications for reversing existing impacts or rehabilitation. A study was conducted to establish the effectiveness and efficiency of various plants in reducing degradation of freshwater ecosystems in South Africa, especially in urban and peri-urban environment. The study has shown that the establishment of buffer zones to rivers, estuaries and wetlands can play a meaningful role in reducing impacts to aquatic resources and in so doing, protect the range of services that these resources provide to society. Plants are the main components of the buffer zones protecting water resources and each type has a significant role that it plays in the whole ecological systems working as a natural infrastructure to secure water, food, medicines, and energy for the society.

Keywords: buffer zones, ecological infrastructure, ecosystem services, freshwater, and plants

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78. Lounes-Hadj Sahraoui, Anissa

Arbuscular mycorrhizal fungi-assisted phytoremediation: a green technology for cleaning-up aged polluted soils.

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To restore polluted soils, phytoremediation was found to be a feasible approach for in situ clean up of surface soils. It offers the great advantage of being inexpensive, environmentally friendly and not altering the soil matrix. However, phytoremediation efficiency might firmly rely on the settlement of appropriate vegetation which closely depends on the pollutant tolerance of plants. It is within this context that arbuscular mycorrhizal symbiosis represents a challenge for sustainable development. Our findings showed that this issue is based not only on the exploitation of its potential to remove pollutants but also on its ability to protect plants against pollution. The relevance of arbuscular mycorrhizae in phytoremediation of polluted soils by different harmful pollutants (polycyclic aromatic hydrocarbons (PAHs), Dioxins/furans and metallic trace element (MTE)) will be discussed thanks to a feedback from laboratory to field scale experiments. The benefits of arbuscular mycorrhizal inoculation (by Glomus irregulare or by a commercial inoculum) in many plant species (Chicorium intybus L, Miscanthus giganteus, Trifolium repens L, Lolium perenne L and Medicago sativa L) on the growth, the tolerance and the removal of PAHs, dioxins/furans and MTE were studied. In addition, our data contribute, at the mechanistic level, to a better understanding of the mycorrhizal colonization role in plant protection against the pollutant toxicity. They demonstrated that the mycorrhizal plant tolerance resulted from oxidative stress alleviation and lipid regulation which lead to the limitation of membrane and genome damages.

Keywords: phytoremediation, arbuscular mycorrhizae, PAHs, dioxins/furans, MTE, oxidative stress, lipids

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78. Ludlow, Amanda

Incorporating Vegetative Solutions into Landfill Closure along the Buffalo River

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As part of the New York State Brownfields Cleanup Program, Roux Associates designed and implemented a comprehensive assessment and remediation plan for the capping and closure of a former municipal landfill located in an active petroleum distribution terminal along the Buffalo River. To improve the resiliency of the remedial design, as well as enhance the beneficial end use of the land, the design incorporated various innovative vegetative solutions into the overall closure plan:

1. Bio-engineered slope design to stabilize the eroding river shoreline;
2. Stormwater treatment wetland to manage runoff from the impermeable cap surface; and
3. Native woody plant species in combination with a deeper soil cover to enhance the overall wildlife value of the closed landfill and improve stabilization of the surface soils.

This presentation will provide an overview of the remedial design, present the benefits of incorporating vegetation into remedial closure, and share photographs of the completed closure.

Keywords: bioengineered slope stabilization, stormwater, treatment wetland, landfill, wildlife habitat

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78. Ma, Chaunxin

Titanium Dioxide Nanoparticles Exposure Lower the Toxicity of Tetracycline to Arabidopsis thaliana and Oryza sativa

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Antibiotics and nanomaterials (NMs) have been used to control bacterial and fungal diseases in breeding industry and agriculture. More than 70% antibiotics and their intermediate metabolites are discharged into the environment. As rapidly rising demand for and use of nano-enabled products in agriculture in agriculture, large amounts of NMs have been introduced into the field soil. It is very possible that NMs and antibiotics are co-existing in the environment and field soil. However, the studies related to the effects of co-contaminants on plants are rarely been pursued. In this study, we choose titanium dioxide nanoparticles (TiO2 NPs) and tetracycline (TC) as contaminants, both of which are commonly used in agriculture. We investigated the response of Arabidopsis and rice to co-contaminants at physiological and molecular levels. Our results showed that TiO2 NPs could reduce the toxicity of TC to both Arabidopsis and rice. Plants co-treated with TiO2 NPs and TC attained significantly higher biomass than only TC treated groups. The TC concentrations in rice shoot and root tissues decreased as exposure doses of TiO2 NPs increased. Activities of ROS scavenging enzymes were elevated in only TC treated groups as compared to co-treated groups. Further studies including expression levels of genes involved in detoxification pathway (sulfur assimilation and GSH biosynthesis), nutrient levels, and seed development are currently underway. These studies will provide useful information on understanding the fate, transport, and toxicity of co-contaminants in the agricultural crops and to further establish the assessment system for ecological and health risks.

Key Words: Arabidopsis thaliana; Oryza sativa; titanium dioxide nanoparticles; tetracycline; detoxification

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79. Ma, Xingmao

Bioavailability of Cerium Oxide Nanoparticles to Plants: Impact of Soil Properties and Contaminant Aging

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Cerium oxide nanoparticles (CeO2-NPs) are a popular component of many commercial products. Its release into the environment has attracted significant attention in the past and many studies have been carried out to evaluate the fate and transport of cerium oxide nanoparticles in the environment, including their uptake and accumulation by plants. However, the majority of previous studies were conducted in hydroponic systems, ignoring the compounding effect of soil on the fate and transport of cerium oxide nanoparticles. This study examined the effect of soil properties on the bioavailability and accumulation of cerium oxide nanoparticles by radish. Two soils: loamy sand and silty loam were used in the investigation. The results indicated that soil properties such as the clay content, and the content of organic matter, significantly affected the fractionation of cerium oxide nanoparticles in soil and their bioavailability to radish. Even though cerium oxide nanoparticles associated with Fe-Mn oxides and organic matters may be bioavailable to radish, but only the exchangeable fraction appeared to be transported to plant shoots. Once in plant tissues, the distribution and localization of cerium oxide nanoparticles were also affected by soil properties. We further examined the aging effect of cerium oxide nanoparticles on their bioavailability to radish. As some other heavy metals, the aging process reduced the bioavailability of cerium oxide nanoparticles, possibly due to their penetration to the soil pores inaccessible by plant roots or their stronger interactions with soil particles over time. Detailed results will be presented and underlying mechanisms discussed.

Keywords: cerium oxide nanoparticle, aging, loamy sand, sandy loam, radish

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80. Maestri, Elena

Phytoremediation and Environmental Risk Assessment (PhytERA): a new approach

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The PhytERA method has been developed to perform the Environmental Risk Assessment applied to a project of phytoremediation in contaminated soils. PhytERA is based on the assumption that, in order to produce an environmental effect, the presence of three components and their interconnections is required: source – diffusion factors - receptors; in the absence of even one of the components, the risk does not occur. The source of risk is the process of phytoremediation itself; the diffusion factors depend on the characteristics of the plants; the receptors can be various environmental components. Furthermore, a secondary source can be identified when using an alien plant species in the phytoremediation process.
The PhytERA method includes a Conceptual Model, represented graphically as a flow chart, and an electronic questionnaire, which is composed of 289 questions, driven by an application running in Microsoft Office Access, developed ad hoc. The electronic questionnaire, according to the information provided at each step, automatically leads the user to follow individual paths starting at the source(s) of risk, considering the individual diffusion factors and receptors, arriving to identification of specific environmental effects on a case-by-case basis. At the completion of the questionnaire, the user can print a report containing all the information entered and the list of potential effects which have been identified.
The questionnaire and Conceptual Model have been applied to different risk scenarios, using both simulated and real data, in collaboration with phytotechnology researchers. The results of application have confirmed that PhytERA can be applied ex-ante to identify potential effects, and ex-post to implement targeted measures of risk management and to set up specific monitoring plans.

81. Majumdar, Sanghamitra

Nanoceria modulates the kidney bean proteome and compromises Its nutritional quality

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Nanoceria (nCeO2) has gained a lot of attention due to its wide scope of applications including biomedicine, agriculture, fuel catalysts, electronics and planarization. However, knowledge on its impact on the food quality and the cellular mechanisms associated with nanotoxicity is rather limited. In this study, kidney bean plants (Phaseolus vulgaris) were grown in organic matter enriched soil amended with 0-500 mg/kg nCeO2. After a full life cycle exposure, plant yield and nutritional parameters of the harvested seeds were assessed. Ce and mineral contents were measured in the pod tissues (carpels and seeds). To elucidate the cellular mechanisms for nano-bio interaction, seed proteomic analyses were performed using LC-MS/MS spectrometry. A dose-dependent accumulation of Ce was noted in the tissues, statistically significant at 250 and 500 mg/kg nCeO2 (160 and 204 µg/kg, respectively in carpels, and 30 and 23 µg/kg, respectively in seeds). Interestingly, especially at 125 mg/kg nCeO2, plant yield and content of boron and starch in the seeds increased compared to control, but iron, sodium, and crude protein contents in the seeds decreased. As revealed through proteomic analysis, defensin and purple acid phosphatase were up-regulated at 125 and 250 mg/kg nCeO2, primarily associated with stress response and nutrient acquisition. However, the number of down-regulated proteins increased in dose-dependent manner. Down-regulated proteins were associated with seed metabolic activities, nutrient storage, micronutrient binding and accumulation as well as energy transfer. These findings suggests that nCeO2 can enter the food chain through the edible plant tissues and also affect the food quality.

Keywords- Nanoceria, Food quality, Proteomics

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82. Mandal, Asit

Effect of arsenic Levels and phosphate management on phytoextraction efficiency of Chinese brake fern (Pteris Vittata L.)

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A greenhouse experiment evaluated the effectiveness of phosphatic fertilisers such as di-ammonium phosphate (DAP) and single superphosphate (SSP) and two subsequent growing cycles on As removal by Chinese brake fern from (Pteris vittata L.) the contaminated Typic Haplustepts soils. Arsenic uptake status in the biomass was assessed and As translocation and bioavailability factors were measured. It was found that the total As removal in contaminated soil ranged from 8.2 to 16.9 mg pot−1 and from 5.5 to 12 mg pot−1 in the first and second growing cycle respectively, whereas in spiked soil it was 19.4 to 44.5 mg pot−1 and from 10.4 to 32.1 mg pot−1 in the first and second growing cycle respectively. The changes in total As concentration in the rhizosphere were also measured. One cycles of phytoextraction with Pteris vittata removed total soil As at a maximum of 20% from the contaminated soil, which increased up 38% after two successive growing cycles. In As spiked soil, these values were 14% after the first growing cycle and 24% after the second growing cycle. The availability of As was increased due to the application of SSP and DAP which consequently enhanced the bioconcentration factor. The translocation factor of As in P. vittata were not significantly affected by either type of phosphatic fertiliser or growing cycle in contaminated soil, but varied substantially in spiked soil. Phosphate nutrition through DAP combined with two successive harvests by Pteris vittata emerged as the promising management strategy for the remediation of As contaminated soil.

Keywords: phytoextraction, chinese brake fern, arsenic, phosphorus

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83. Marmiroli, Marta

CdS quantum dots and CdSO4: different oxidative stress responses and uptake in A. thaliana w.t.

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Sessions: Nanoscale contaminants or Plant-nanoparticle interaction
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Plants of A. thaliana(L. erecta) w.t., were tested in vitro at three times of growth (15,30, 45 d.) with three different concentrations of either CdSQDs or CdSO4. The contaminants were supplemented in agarised MS medium respectively as water-soluble nanoparticles or as salts at concentrations corresponding to 0, 1/3 MIC, 2/3 MIC (MIC being the minimum concentration for growth inhibition, already calculated in previous experiments). Plants were analyse for their water content, fresh and dry weight, total Cd concentration (flame-AAS), chlorophylls and carotenoids content in leaves (absorbance at different wavelengths), leaf respiration (TTC assay), total phenolics, ABTS, and DPTH. ESEM/EDX was used to observe leaf and roots at high magnification to detect morphological changes at the level of organ and tissues, microanalysis was performed to verify Cd uptake from the roots, root-shoot translocation and identify possible sinks for Cd storage for all types of treatments. These parameters were used to establish a correlation between the oxidative stress response of the plants at different contaminants, at different concentrations and varying the time of growth with the nature of the treatment (Cd-containing nanoparticles or Cd bulk material). Taking into account the natural senescence process of A. thaliana (particularly evident after 45 days), we evidenced substantial differences in the response of the plants to the two types of contaminants. Where CdS QDs are more toxic than CdSO4, and preferentially stored into plant tricomes, while Cd ions are mainly concentrated in the roots and move to the shoots more rapidly.

Keywords: CdS QDs nanoparticles, Cd bulk material, A.thaliana, oxidative stress

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84. Marmiroli, Marta

Two cv. of Solanum lycopersicum treated with As and As+Si: differences in As uptake, localization, oxidative stress response and proteomic profile

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Cultivars Aragon and Gladis of Solanum lycopersicum were sown in punched-wells polystyrene boxes on common garden soil, after several transplants, they were settled (one plant) in 12-L pots in a greenhouse under controlled conditions. One hundred days after sowing (T0), three plants every batch of 12, where harvested: all organs (roots, leaves, stems, fruits). Two batches were treated either with 5mg/L As (AsNaO2) or 5mg/L As (AsNaO2) plus 2mg/L Si (CaSiO3), one was left as control. After 48 hours (T48h) and 15 days (T15d), three replicates for treatment were collected along with their soils. Total As was measured with AAS for each plant organ and soil; TFs, BCFs were calculated accordingly for each organ, time and type of treatment. We measured in leaves and fruits oxidative stress response indicators, such as respiration, chlorophyll and carotenoids, total phenolics, DPPH, ABTS, total GSH (GSSG, GSH in redox state), lipid peroxidation, total ROS. Cross-sections of all organs were analysed for morphological changes at cellular level with optical and ESEM microscopy, SEM/EDX microanalysis was used for As, Si and mineral nutrients localisation within each organ. Total proteins were extracted from fruits and leaves (for each type/time of treatment), separated through 2D-SD-PAGE gels, stained with Comassee blue. Significant spots were cut, de-stained, digested with trypsin, run through MALDI-TOF to obtain peptides mass fingerprints, which were searched and identified in silico. Significant difference were found between cultivars, in all quantities and parameters, depending mostly on the treatment length and Si addition.

Keywords: Arsenic, Tomato cvs., Silicon, As accumulation, plant response to As

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85. Marmiroli, Marta

Basis for cadmium sulphide quantum dot tolerance and sensitivity: a genome-wide nanotoxicology screening of Saccharomyces cerevisiae mutants

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The use of cadmium sulphide quantum dots (CdS QDs) is increasing, particularly in the electronics industry, but their size (1-10 nm in diameter) is small enough for them to be taken up by living cells. Here, a bakers' yeast (Saccharomyces cerevisiae) deletion mutant collection has been exploited to provide a high-throughput means of revealing the genetic basis for tolerance /susceptibility to CdS QDs exposure. The deletion of 112 genes, some associated with the abiotic stress response, some with various metabolic processes, some with mitochondrial organization, some with transport and some with DNA repair, reduced the level of tolerance to CdS QDs. A geneontology analysis highlighted the role of oxidative stress in determining the cellular response. Transformation of sensitive mutants with centromeric plasmids harbouring DNA from a wild type strain restored the wild type growth phenotype when the complemented genes encoded either HSC82, DSK2 or ALD3. The use of these simple eukaryote knock-out mutants for functional toxicogenomics analysis will inform studies focusing on higher organisms.

Keywords: CdS Quantum Dots, functional toxicology, yeast mutants, gene ontology analysis.

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86. McLaren, James

Development of Bioproducts from Camelina

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One of the growing sustainable development challenges is making good use of marginal environments. Camelina can be produced on land where precipitation is limited. Research has been carried out to investigate potential bioproducts from camelina seeds. Cold pressing has been used to produce an oil product for use in foods and feeds. Extraction of oil with a solvent such as hexane yields an oil that has potential as a biofuel. The protein fraction of the meal can be used in adhesive applications. The remaining meal has several potential uses. Process engineering and life cycle analysis have been used to investigate environmental impacts and commercial viability of alternatives. Recent genetic developments to increase the content of omega-3 long-chain polyunsaturated fatty acids in camelina seeds have enhanced interest in the cold pressed oil product and improved the economics of producing camelina.

Keywords: camelina, arid soil, bioproducts, process design, life cycle analysis, adhesives, oil

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87. Melgouli, Hacène

Arbuscular mycorrhizae efficiency in dissipation of dioxins/furans from aged-polluted soil: a microcosm experiment

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Soil pollution, a difficult environmental problem, has been attracting considerable public attention over the last decades. Several organic persistent pollutants are found in contaminated soils including dioxins/furans (PCDD/F). These contaminants are harmful both for environment and human health (immunotoxicity, neurotoxicity, carcinogenicity). PCDD/F are characterized by high hydrophobicity and recalcitrance to oxidation, which make them highly resistant to degradation. In the current work, Arbuscular Mycorrhizal Fungi (AMF) –assisted phytormediation is proposed to restore aged PCDD/F polluted soil. This technique is environmental friendly, potentially cost effective and not altering the soil matrix. Moreover, AMF improves the phytotechnology effectiveness by providing protection to the plants against the pollutant toxicity and by enhancing pollutant dissipation. The contribution of mycorrhizal inoculum Solrize® (Glomus sp) addition on the ability of four plant species (Clover, Alfalfa, Ryegrass and Tall fescue) to grow and to dissipate PCDD/F was assessed after 20 weeks of microcosm culture. Our findings showed that the four plant species were able to grow on the soil despite the presence of PCDD/F at the concentration of 200ng/kg. Total and arbsucular mycorrhizal colonizations of 70 and 30% respectively, were obtained after 20 weeks of culture. PCDD/F residual concentrations in the soil were reduced in the presence of the vegetation. A dissipation of 20% was obtained with Tall fescue. This dissipation was found to be due to the stimulation of the microflora measured through the enzyme activities (FDA hydrolases and dehydrogenases) and bacterial flora, evidenced by bacterial Phospholipid Fatty Acids (PLFA).

Keywords: phytoremediation, arbuscular mycorrhizae, dioxins/furans, aged polluted soil

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88. Mehdawi, Ali F. El

Analysis of selenium accumulation, speciation and tolerance of potential selenium hyperaccumulator Symphyotrichum ericoides

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Symphyotrichum ericoides was found to contain hyperaccumulator levels of Se (up to 4,000 mg kg-1 DW) on a seleniferous field site. It often grew next to other Se hyperaccumulators Astragalus bisulcatus and Stanleya pinnata, where it was on average 2-fold larger and suffered less herbivory than when growing next to non- hyperaccumulators (El Mehdawi et al. 2011b). This raised two questions, whether S. ericoides is capable of hyperaccumulation without neighbor assistance, and whether its Se-derived benefit is merely ecological or also physiological. In a comparative greenhouse study, Se accumulation and tolerance of S. ericoides were analyzed in parallel with hyperaccumulator A. bisulcatus, Se accumulator Brassica juncea and related Asteracea Machaeranthera tanacetifolia (El Mehdawi et al. 2014). Symphyotrichus ericoides showed very high leaf Se/S and shoot/root Se concentration ratios, similar to A. bisulcatus and higher than M. tanacetifolia and B. juncea. Se X-ray absorption near-edge structure spectroscopy showed that S. ericoides accumulated Se predominantly (86%) as C-Se-C compounds indistinguishable from methyl-selenocysteine, which may explain its Se tolerance; the remainder was inorganic Se. Thus, in the greenhouse study S. ericoides¬ displayed all of the characteristics of a hyperaccumulator; whether it can hyperaccumulate independently in the field requires more investigation. The bigger size displayed by the high-Se S. ericoides¬ growing next to hyperaccumulators may be explained by a Se-related physiological benefit, in addition to the ecological benefit demonstrated earlier. These findings are useful for the management of seleniferous areas and cultivation of Se-rich crops for phytoremediation or biofortification.

Key words: hyperaccumulation, Astragalus bisulcatus, Brassica juncea, Machaeranthera tanacetifolia, X-ray absorption spectroscopy.

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Acknowledgements: Financial support for these studies was provided by US National Science Foundation to EAHPS.

89. Michel-López, CY

Bioaccumulation and changes in the photosynthetic apparatus of Prosopis juliflora exposed to cadmium

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The effect of copper toxicity on the photosynthetic activities and bioaccumulation in different tissues of Prosopis juliflora was investigated using three CdCl2 concentrations (50, 100, and 1000 µM) added under hydroponic conditions. Cadmium concentration and chlorophyll fluorescence were measured after 48 h of cadmium stress. The results that metal analysis showed that the root tissue of plants exposed to P. juliflora increasing doses of metal accumulated significantly over time. However, P. juliflora exposure to high doses of Cd2+ were those that showed increased accumulation of metal at the end of the experiment compared to the control plants. On the other hand, when plants of P. juliflora were treated with increasing doses of Cd2+, the values of photosynthetic efficiency (Fv/Fm) of P. juliflora no showed significant change after 48 h of treatment with the metal. Similarly, the values of (F0/Fv) and (Fv/F0), respectively, showed no significant change with increasing doses of metal relative to the control after 48 h of treatment. Therefore the information provided by this short-term (48 h) experiment showed that several physiological processes are activated, in which the cadmium uptake by roots and their accumulation in tissues play a central role. In conclusion, the chlorophyll fluorescence parameters can be used as a useful physiological tool to assess early changes in photosynthetic performance of P. juliflora in response to cadmium pollution in short-term. Finally, the present study showed that P. juliflora is a promising prospect for heavy metals phytoremediation purposes occurring in arid and semi-arid climates in the northwest Mexico.

Keywords: bioaccumulation, chlorophyll fluorescence a, heavy metals, Prosopis juliflora

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90. Mirza, Nosheen

Modeling the removal of hexavalent chromium, adsorbed by least cost organic wastes and optimization of flame atomic absorption spectrophotometer (FAAS), for economic and accurate chromium determination

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The efficiency of non-conventional, least cost organic wastes, for chromium adsorption, was investigated through batch experiment, at the laboratory of Environmental, Agricultural and Analytical Chemistry, School of Chemistry, University of Glasgow, Glasgow, United Kingdom. Organic wastes such as, pine bark, garden peat, fresh ash, coconut shell, coconut fiber, straw and green goodness, compared with the blank (control), using Completely Randomized Design (CRD), in three replications, were used as filter beds for chromium Cr(VI) adsorption. For highest accuracy of Cr(VI) analysis, by flame atomic absorption spectrophotometer (FAAS), and a step towards energy and economy conservation, the flame composition of agitation gas (ethylene gas (C2H2)) of FAAS, was evaluated for optimization. Langmuir and Freundlich isotherm models for Cr(VI) adsorption by organic wastes, were analyzed. Statistically, highly significant ($P \leq 0.01$) differences in Cr(VI) adsorption by organic wastes were revealed. The efficiency of adsorbents was in the order of PB > GP > FA > CS > CF. Amongst all, the highest adsorption was by pine bark (98%) and garden peat (96%). Calculation of ethylene consumption serving as additional fuel, in Cr(VI) determination per treatment, revealed that at higher flow rates, C2H2 had no impact on Cr(VI) determination. Thus, to avoid and terminate the effect and wastage of C2H2, the flame composition of agitation gas was recommended to be optimized.

Keywords: Cr(VI), least cost - agriculture wastes, filter bed, adsorption, adsorption isotherm, ethylene, flame atomic absorption spectrophotometer (FAAS).

91. Mishra, Soumya Ranjan

Adsorption of Cd(II) from aqueous solution using Azadirachta indica (Neem) leaves

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Heavy metals are major toxicants found in industrial wastewaters and may adversely affect the environment, if left untreated. Cadmium (Cd) is one such metal that enters into the environment due to anthropogenic activities. Conventional methods for the removal of heavy metals from waste waters are often cost prohibitive. Thus, we made an attempt to explore alternate technologies for the removal of toxic metal from the environment. For this purpose, removal of Cd(II) from the aqueous solution by a non-conventional biosorbent i.e. Neem leaves powder (Azadirachta indica) was examined. Batch mode experiments were conducted to study the effects of agitation time, adsorbent dose and Cd(II) concentrations.

The kinetic data obtained at different concentrations was analyzed using pseudo-first-order and pseudo-second-order equation. The experimental data fitted very well the pseudo-second-order kinetic model. The absorption of Cd(II) on neem leaves powder was rapid initially (93.42%) and reached the peak in 180 min of agitation (96.95%). The experimental data were analyzed by the Langmuir, Freundlich and Temkin models of adsorption. Adsorption data revealed best fit for Freundlich isotherm. The adsorbent dose indicated instantaneous adsorption (92.78%) at a dose of 0.4 g and reached equilibrium at 1.6 g dose. The removal of Cd(II) was dependent on its concentration. The experiment reveals a good potential of neem leaves powder, a cost-effective adsorbent, in the removal of Cd(II) from aqueous solution.

Keywords: Adsoprtion, Isotherms, Kinetics, Neem

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92. Moameri, M.

The potential of native plants for phytoremediation of contaminated soils with Lead and Zinc (Case Study: The rangelands of around National Iranian Lead & Zinc Factory-Zanjan) M. Moameri*1, M. Jafari2, A. Tavili3, B. Motasharezadeh3 and M.A. Zare Chahouki3

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There are many methods used for remediating heavy metals pollution but only phytoremediation is a cost effective, environmental friendly, aesthetically pleasing approach most suitable for many countries. The purpose of this study was to investigation the potential of native plants for phytoremediation of contaminated soils with Lead (Pb) and Zinc (Zn) in the rangelands of around National Iranian Lead & Zinc Factory-Zanjan. Sampling was performed at the 11 sites on May, 2014. Plant samples were collected from six native plant species including Stipa hohenackeriana, Hulthemia persica, Gundelia tournefortii, Brassica juncea, Astragalus effesus and Taeniatherum crinitum from 11 sites. Three soil samples were taken at each site. Soil samples were taken from the rooting zone (0–20 cm). Extraction of Zn and Pb from plants and soil samples was done by acid digestion. Metals of Zn and Pb extracted from plant and soil samples were determined using Inductively Coupled plasma Optical Emission Spectroscopy "ICP-OES" (software v4.1.0b443, GBIP v1.7b2). In general S. hohenackeriana and H. persica two species of native plants that have the potential to be used for phytoextraction of Pb contaminated soil and S. hohenackeriana, H. persica and A. effesus have the potential to be used for phytoextraction of Zn. In other words, these three plants are good candidates for phytoremediation of Pb and Zn pollution soil in study area.

Keywords: Native plants, soil contaminated, Lead, Zinc, Iran

93. Mohanraj, R.

Sodic soil remediation in a semi-arid region involving organic amendments and vegetative remediation by Casuarina equsetifolia and Erianthus arundinaceus
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In arid and semi-arid regions of the world, certain unsystematic farming practices and land management result in saline-sodic soils. This investigation is an experimental attempt using a combined approach of biological and phytoremediation methods to ameliorate sodic soils. The study was carried out in a semi-arid region of Southern India, where excess irrigation in the uplands has resulted sodic soils at low-lying areas. The combined approach involved organic manuring, green manuring with Sesbania rostrata and subsequently phytoremediation by plantation of Casuarina equsetifolia and Erianthus arundinaceus clones. The use of Erianthus arundinaceus in the integrated treatment along with other amendments is first of its kind in the region and about 20% of reduction in Exchangeable Sodium Percentage (ESP) was achieved over the initial values. The initial values of ESP in the control plot as wells as treated plot at three different depths varied between 44 – 42.3%. In response to organic amendments followed by Casuarina and Erianthus plantations, the ESP reduced to 35 - 36.5%. Phytoremediation in combination with other amendments significantly improved the major and micro nutrients besides nurturing the soil micro-organisms and enzyme activity. The survival percentage of the ranged crops from 81 percent to 92 percent, and the cost-benefit ratio based on the market demand for pulpwood ranged between 1:1.75 and 1:2.05. The integrated approach for reclamation of sodic soil has been found to be an efficient, cost effective and environmentally sound strategy for semi-arid regions.

94. Mohanraj, R.

Screening CO2 sequestration efficient Pulp wood species in OTC under elevated CO2 conditions

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Two commercially grown common varieties of pulp wood Eucalyptus camaldulensis and Eucalyptus tereticornis are experimented in OTCs under elevated CO2, climate stress conditions and nitrogen enrichment. Saplings of two clone varieties of Eucalyptus tereticornis (C3 and C7) and a hybrid variety of Eucalyptus camaldulensis+Eucalyptus tereticornis (2135) obtained from Tamilnadu News Print Ltd were subjected for experimentation. After 30 days of trial experiments, actual experiment was initiated with triplicate saplings of each variety subjected following treatments: T1) ambient conditions outside the OTC, T2) elevated CO2 (450 PPM), T3) elevated + nutrient enrichment, T4) elevated + water stress. After 60 days the saplings were harvested and analyzed for a number of parameters including frsh biomass, dry biomass, productivity, leaf area index, chlorophyll content, shoot length, root length etc. Among the Clones of Eucalyptus tereticornis clone C3 registered comparatively good productivity in present day ambient conditions and also under elevated CO2 levels of 450 PPM. However, under elevated CO2 levels with water stress, C7 showed better performance in productivity.

95. Morabito, Domenico

Evaluation of biochar beneficial effects on the phytostabilization of contaminated soils using poplar: influence on metal(loid)s bioavailability

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Over the years, the intense mining and smelting activities have produced many polluted sites due to the release and accumulation of metals and metalloids. Restoring these contaminated soils using low impact and cost-effective remediation techniques has been increasingly investigated. Thus phytoremediation techniques using plants to stabilize soil pollutants could be an optimum solution if using plants demonstrating metal tolerance and an efficient root development. In association with plants, the contribution of biochar obtained by pyrolysis of wood biomass and applied at low concentration in a soil could improve the soil quality and optimize the phytostabilization of metal(loid)s.

The aim of this study was to assess the effects of Populus euramericana genotype Dorskamp in association with biochar (2% or 5%) on soil pollutant bioavailability. In our tests, biochar significantly increased the water retention of the two anthroposols studied, whereas its alkaline nature induced an increase in soil pore water pH and electrical conductivity. Concomitantly, with observed a significant reduction of metal(loid)s (Pb, Cd, Zn and As) bioavailability in soil pore water. At the end of the experiment, poplar rooted cuttings were divided into cutting, roots, stems and leaves in order to evaluate the metal repartition. It has been demonstrated that biochar induced an higher biomass production compared to control whereas metal(loid)s content in the different poplar organs decrease. In conclusion, we demonstrated the powerful potential of biochar both to improve soil quality and to reduce metal(loid)s availability, increasing the chances of a successful phytoremediation.

Keywords: biochar, phyostabilization, poplar, metal(oid)s, bioavailability

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96. Morató, Jordi

Stormwater management with natural drainage water filter: Altos de la Estancia, a case study

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Altos de la Estancia is located in the south of Bogota, in Ciudad Bolivar. It shares borders with Carbonera, Los Rosales, and Santa Rita ravines, which have produced multiple instabilities during recent decades deepened by many human actions. Two landslides occurred in 2002 and 2003, affecting approximately 73.18 ha. Since then, the area was declared Soil of Protection for Risk in 2012, implementing various measures to recover the ground and mitigate the risk conditions caused by irregular discharges of water. During 2014, actions to manage runoff were developed through the construction of a natural drainage water filter, made with bamboo (Guadua) that allowed a safe collection and transport of water to safe points, reducing infiltration and water saturation in the specific areas with higher stagnation problems. The proposed design was executed by the community as a part of a social strategy for land appropriation and to strengthen their capacities and social skills for the implementation of adaptative practices of an integrated recovery. Two natural drainage water filter were built with bamboo (Guadua angustifolia Kunth) and geotextile at the rate of 1.5 m deep, with fences spaced every 3.0 m on average. Sambucus nigra L. trees were planted along the trench and moisture measurements were taken to determine the impact on soil desaturation. A hydrologic model was built based on flow and rainfall measurements on the field and the rainfall historical record, in order to establish the hydraulic energy loss efficiency alongside the natural drainage water filter system.

Keywords: natural drainage water filter, mass removal, water runoff, Guadua.

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97. Morató, Jordi

Effect of buffer strips on runoff and leachate production for restoration of an old dump garbage in Medellin.

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Moravia hill is a 35-meter old dump located in Medellin, Colombia. It was generated between 1977 and 1984, presenting major issues at social and environmental level. During last 5 years a relocation project of the families living in the dump have been developed, and an integral and sustainable approach for a proper management of surface runoff, treating infiltration and leachate production have been established during the last 3 years, using natural treatment systems. Treatments used are based on appropriate technologies, like constructed wetlands and buffer strips. The project has evaluated the effect of buffer strips on surface runoff, leachate generation and bioaccumulation of Chromium and Lead. Five plots with different vegetal composition were built and monitored, including three species in monoculture -Ruellia simplex (P2), Penysetum alopecuroides (P3) and Tradescantia pallida (P4)-, one control with no vegetation (P1) and other control with a mixture of spontaneous native vegetation (P5). Buffer strips reduced the runoff volume between 50 and 90%. According to this study, the most suitable combination of species to decrease the runoff and leachate production corresponds to Ruellia simplex (P2) plot and the native vegetation (P5). On the other hand, the transfer of heavy metal from the soil has been studied. Pb and Cr levels in soil range between 403.2 to 489.1 ppm and 166 to 241 ppm respectively. The levels of Pb in plants were low, but high levels of Cr were observed, mainly on the roots (144 ppm max.) and the stems (64 ppm max.).

Keywords: heavy metals, plot, bioaccumulation, sustainability.

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98. Mudumbi, John Baptist Nzukizi

Removal of perfluoroalkyl compounds using Agave sisalana microporous activated carbon fibre

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In this study, the removal of perfluoroalkyl compounds (PFCs) using Agave sisalana activated carbon fibre (ACF), is discussed. In a recent study, PFOA and PFOS were found to be prevalent in raw and drinking water samples from the largest catchment areas of the region, i.e. Western Cape, South Africa. In order to remove these perfluoroalkyl contaminants, ACF was manufactured using several activation reagents coupled with a spray-drying technique, with the optimum determined as 0.54M, 0.625M, 1.59M and 0.73M for KOH, NaOH, ZnCl2 and H3PO4, respectively. The ACF activated with KOH (0.54 M) was characterized by micropores with a BET surface area of 1285.8 m2/g. From the adsorption results, the minimum removal rates observed were 65.55% for PFOA and 95.92% for PFOS. Subsequently, the ACF with the highest removal rates, was used in: 1] sonication and 2] an electro-physico-chemical adsorption studies, to facilitate the rapid adsorption of PFOS and PFOA from contaminated drinking water. The result indicated that the adsorption of PFOA and PFOS on ACF was a monolayer adsorption type described by the Freundlich isotherm. It was concluded that PFOA and PFOS loading was successfully achieved using Agave sisalana ACF under various conditions.

Keywords: Agave sisalana; Activated carbon fibre; Perfluorooctanoate; Perfluorooctane sulfonate

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99. Muliadi, Deasy Liestianty

The Effect of Compost and Charcoal Waste on Phytoremediation Cadmium-Contaminated Soils by soybean (Glycine Max (L) Merrill)

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The effect both of compost and charcoal waste on phytoremediation Cadmium-contaminated soil using soybean (Glycine Max (L) Merrill) was conducted. The aims of research are to determine the effect of adding both of compost and charcoal waste and examine the feasibility of soybean (Glycine Max (L) Merrill) as Cadmium-hiperakumulator plant. The analytical method used is voltammetry methods. The results of research that indicated the concentration of cadmium on control pots, addition of compost and charcoal respectively 360.46 mg/g; 216.68 mg/g and 323.09 mg/g. The addition both of compost and charcoal waste was capable inhibiting cadmium into the plant. Soybean (Glycine Max (L) Merril) was categorized as cadmium-hiperakumulator plant with Translocation Factor> 1.

Key words: Phytoremediation, Cadmium, compost, Charcoal, Soybean

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100. Naudi, Ravi

Contaminated Sites Management: A Risk-Based Approach

Ravi Naidu*, Cooperative research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) and University of Newcastle

It is now recognised that globally there are more than 5 million potentially contaminated sites. Given the risk that contaminants pose to environmental and human health, developing countries currently spend more than $30 billion per annum managing or remediating such sites. Despite growing awareness of this risk, activities that contribute to contamination of our environment persist in many countries because industry fails to adhere to regulatory criteria. It is estimated that less than 20% of contaminated sites in developing countries have been remediated. Uncertainties about the nature and extent of contamination can be a major constraint to sustainable development in both cities and rural areas, thereby increasing pressure on the use of limited uncontaminated land. Moreover, many techniques available for in situ or ex situ remediation are prohibitively expensive and thus poorly adopted.
Soil is now seen as a complex heterogeneous system that, once contaminated (especially when coupled with groundwater) is not easily repaired. Furthermore, drastic risk control (e.g. cleaning up sites to background concentrations or to levels suitable for sensitive land use) is neither technically nor economically feasible. It is thus desirable to apply remedial approaches that reduce the risk of contamination while allowing the soil to remain on site. This approach to site remediation, which is gaining increasing acceptance, is commonly known as risk-based land management. This paper presents an overview of the underlying basis of this approach – namely contaminant bioavailability and its implications to environmental and human health – and explores case studies of its application in Australia.

Keywords: soil, contaminants, risk, remediation

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101. Naidu, Ravi

Soil: The Critical Zone for Sustainability

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The 'critical zone' can be defined as "the portion of the Earth's land surface that extends from the lower limit of freely circulating groundwater to the top of the vegetation canopy". The functioning of this zone determines the rates at which mass and energy are exchanged among the regolith, biosphere and atmosphere. This zone also affects the way in which ecosystem services function and hence influences food security including clean water and a balanced atmosphere. Although our ancestors recognised that the functioning of the critical zone underpins our survival, the ever increasing demand for human needs – such as food transport or resources – has had dire impacts upon soil in many countries. Such impacts on soil can be caused by deforestation, salinisation and environmental contamination. Soil degradation via contamination affects every individual on this planet, not only directly but also through harm to local and international trade and our climate. Recent estimates suggest that unsustainable land-use practices, including some types of mining, exhaustive agricultural practices and other industrial activities, have resulted in soil losses at a far greater rate (100 times or more) than soil formation. In arguing that soils must be considered a precious finite resource, this paper presents an overview of the role of soils in the critical zone by taking into consideration unsustainable land use in general and the impact of contaminants on soil productivity in particular.

Keywords: soils, productivity, ecosystem services, contaminants

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102. Naidu, Ravi

Contaminated Sites Management: A Risk-Based Approach

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It is now recognised that globally there are more than 5 million potentially contaminated sites. Given the risk that contaminants pose to environmental and human health, developing countries currently spend more than $30 billion per annum managing or remediating such sites. Despite growing awareness of this risk, activities that contribute to contamination of our environment persist in many countries because industry fails to adhere to regulatory criteria. It is estimated that less than 20% of contaminated sites in developing countries have been remediated. Uncertainties about the nature and extent of contamination can be a major constraint to sustainable development in both cities and rural areas, thereby increasing pressure on the use of limited uncontaminated land. Moreover, many techniques available for in situ or ex situ remediation are prohibitively expensive and thus poorly adopted.

Soil is now seen as a complex heterogeneous system that, once contaminated (especially when coupled with groundwater) is not easily repaired. Furthermore, drastic risk control (e.g. cleaning up sites to background concentrations or to levels suitable for sensitive land use) is neither technically nor economically feasible. It is thus desirable to apply remedial approaches that reduce the risk of contamination while allowing the soil to remain on site. This approach to site remediation, which is gaining increasing acceptance, is commonly known as risk-based land management. This paper presents an overview of the underlying basis of this approach – namely contaminant bioavailability and its implications to environmental and human health – and explores case studies of its application in Australia.

Keywords: soil, contaminants, risk, remediation

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105. Nayyar, Harsh

Halo-tolerant Rhizobacteria (Klebsiella pneumonia and Pantoea dispersa) reduce sodium uptake and enhance growth and seed yield of Chickpea plants grown under salt conditions

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Salt stress is an environmental soil stress with multiple damaging effects on plants including physiological damage and reduced growth and productivity. Plant growth promoting rhizobacteria (PGPR) are one of the viable options where beneficial microbes can be used for mitigating the negative effects of this stress. For this purpose, microbes with plant growth promoting attributes were isolated from the rhizosphere of chickpea, which were found to be salt tolerant (up to 150 mM) under lab conditions. These were further identified by 16S rRNA gene sequencing as PSB1 (Klebsiella pneumoniae subsp. ozaenae), PSB2 (Klebsiella pneumoniae subsp. pneumoniae) and PSB3 (Pantoea dispersa). These isolates were used as inoculants, both individually as well as in cocktail, on a salt-sensitive legume (chickpea) grown in salt supplemented soil (40 and 60 mM NaCl), to evaluate their potential as plant growth promoters. Sodium uptake into leaves and nodules was prevented significantly to improve K/Na ratio. Damage to leaves, photosynthetic function and leaf water status was significantly less in plants growing with PGPR. Maximum increase in yield traits was found with Pantoea sp. (PSB3) individually and combination treatments PSB3 + PSB1 and PSB1 + PSB2 + PSB3 under salt conditions, with a significant improvement by 31-35% (biomass), 20-34% (pods number), 21-36% (seeds number), 20-33% (pods weight) and 25-35% (seeds weight) in contrast to control plants, under salt stress. Our results indicated that consortium treatment was effective and showed relatively better improvement at higher salt concentration (60 mM). Thus, present study suggests that these PGPR with different plant growth promoting attributes can be used together as a consortium on salt stress-affected chickpea plants to provide additional support to reduce stress effects as well as to foster the growth and productivity of chickpea crop.

Keywords: Chickpea, salt stress, Plant growth promoting bacteria, Yield

106. Nguyen, ThanhHung

EFFECTS OF ORGANIC FERTILIZERS ON THE HEAVY METAL ABSORPTION OF BETA VULGARIS L.VAR.CICLA IN SOIL CONTAMINATED WITH CADMIUM

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Abstract

A study about the effects of organic fertilizers on inhibiting heavy metal absorption of Beta vulgaris L.var.cicla (i.e. an agricultural plant capable of absorbing high amount of Cd) in soil contaminated with Cd was conducted through outdoor pot-culture and small-scale field experiments. The results showed that fertilizing 1.8kg cow manure + 0.09kg lime was considered to have the best impact on growth, development and potentially inhibit the Cd absorption of B. vulgaris in particular and agricultural crops in general. Additionally, the lower the pH, the higher the mobility of Cd metal ions was, which strengthened the Cd absorption of B. vulgaris stems. Under pH more than or equal to 7.89, heavy metals tended to link organic compounds to form complexes, which reduced the flexibility and prevented the Cd accumulation in plants. Due to the development of plants organic matter was not washed out. At the same time, the amount of remaining parts such as organic fertilizers, roots, stems and leaves of increased the content of organic matter (OM%), total phosphorus (P%), total potassium (K%) and total nitrogen (N%) in soil.
Key words: Beta vulgaris L.var.cicla, organic fertilizers, Cd, phytoremediation.

107. Nichols, Elizabeth

Mitigation of PPCPs at a Forested Municipal Wastewater Land-Application Site

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Municipal wastewater land application to managed forests is a wastewater management technology that can mitigate nutrients effectively and also provide additional ecological services such as wildlife habitat, groundwater re-infiltration, and carbon sequestration. One uncertainty of these systems is their ability to mitigate pharmaceuticals and personal care products (PPCPs) found in wastewater. This study evaluated the fate of 33 PPCPs at a 3,000 ha facility where primary-treated wastewater has been land-applied to a mixed hardwood, pine forest for 17 years. The wastewater contribution to local hydrology was determined using stable isotopes of hydrogen (2H) and oxygen (18O), chloride concentrations, and specific conductance as environmental tracers as well as conventional hydrometric measurements. Data were used to determine wastewater flow paths and the concentrations of 33 pharmaceutical compounds in wastewater, groundwaters, and surface waters. A mixing model estimated that wastewater comprised on average 24% of the mean daily discharge (13,853 m3/day) at the watershed outlet although percentages increased during times with limited rainfall. Surface waters and groundwaters were evaluated for a suite of 33 pharmaceuticals and steroid hormones. More than half of all compounds detected in irrigated wastewater were not present in groundwaters and subsequent surface waters, indicating removal by the forested soil system.

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108. Noori, Azam

Mycorrhizal Lycopersicon esculentum aquaporines gene expression and physiological responses to silver nanoparticle

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Progress in Nanotechnology during last decades caused vast usage of nanomaterials. Among different types of nanomaterials, silver nanoparticles (NPs) have vast application in different area such as biolabeling, filters and antimicrobials. Antimicrobial properties of Silver NPs led to the use of these nanometals in different fields of medicine, cosmetics, health and agriculture. Diverse application of these products increases their release in to the environment and the risk of taken up by plants. In this study we attempt to determine the impact of sliver nanoparticles on plants physiological and molecular responses in mycorrhizal and non-mycorrhizal plants. Rhizophagus intraradices spores were used to colonize Lycopersicon esculentum (tomato) roots. Mycorrhizal and non-mycorrhizal L. esculentum grown for 60 days were exposed to 25 and 75 ppm of 2nm silver nanoparticles for 20 days. Roots, stems and leaves length and weight as well as mycorrhizal colonization were measured at each treatment. Plants (roots, stems and leaves) and soil were analyzed for silver NP content using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). The highest amount of silver was detected in roots and the lowest in stems. Silver NPs content increased significantly in Mycorrhizal and non-mycorrhizal plants by increasing NPs concentration. Gene expression of Aquaporine genes including TIP, NIP and PIP was measured using Q-PCR. Beta tubulin was used as reference gene. For physiological parameters chlorophyll and anthocyanin content, antioxidant enzymes activity including peroxidase and catalase and antioxidant metabolites including proline, flavonoids and total phenol was measured.

Keywords: ICP-OES, Lycopersicon esculentum, Mycorrhizae, Silver nanoparticles, Gene expression, Physiological analysis

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109. Nsanganwimana, Florien

Appraisal of the potential of the energy crop Miscanthus x giganteus for phytostabilization of trace element contaminated soils: Focus on Cd, Pb and Zn

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Soil contamination by trace elements (TEs) is of major concern worldwide. Phytostabilization is proposed as an environmentally-friendly option for phytomanagement of large surface of TE-contaminated lands. The present study assessed the capacity of the energy crop Miscanthus × giganteus for phytostabilization of agricultural lands located in the vicinity of the former lead smelter (Metaleurop nord, France). In this area, Cd, Pb and Zn concentrations in soils are 20 to 50-fold higher than the regional background values. Miscanthus × giganteus experimental plantations comprised two agricultural plots established around the former smelter, and one agricultural plot considered as a control. Four year after the crop establishment, topsoil (0-25 cm) and plant samples were collected in order to study the soil physico-chemical parameters and TE (Cd, Pb and Zn) mobility, and to establish the relationship between TE accumulation in M. × giganteus organs and the soil physico-chemical parameters. The results shows that M. × giganteus grows quite well on contaminated soils and that this plant did not induce significant changes in TE distribution and mobility in soils. Cadmium, Pb and Zn concentrations in M. × giganteus organs, and their bioconcentration or translocation factors demonstrate that this species accumulates the studied TEs mainly in roots and strongly reduces their transfer to aboveground parts. Moreover, TE concentrations in leaves and stems did not significantly differ between contaminated and uncontaminated plots. Overall, these results show that M. × giganteus is TE-excluder and could be a potential candidate for phytostabilization and biomass production on TE-contaminated agricultural soils.

Key words: Miscanthus, biomass crop, phytomanagement, trace element-exclusion

110. Nurzhanova, Asil

Phytoremediation of DDT-contaminated soils in Kazakhstan

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In Kazakhstan, a deepening ecological crisis has caused by contamination of the environment with obsolete pesticides. Large-scale physical and chemical technologies for managing pesticide-contaminated soils are expensive and unacceptable for Kazakhstan because of limited financial resources. Phytoremediation is a promising innovative technology for managing pesticide-contaminated soils.

Our research focuses on the development of technology phytoremediation soils around the former storehouse's pesticides. Soils around the former storehouse's pesticides were contaminated with organochlorine pesticides: DDT along with their associated metabolites: 2.4'-DDD (2,4'-dichlorodiphenyldichloroethane 4.4'-DDD; 4.4'-DDT; 4.4'-DDE (4.4'-dichlorodiphenyld chloroethylene). Identification of wild plant populations in such conditions demonstrated the stability or tolerance to pesticides. From these studies, 22 pesticide tolerant plant species were selected. Some species Xanthium strumarium, Artemisia annua, Amaranthus retroflexus demonstrated reduction of pesticide concentration in soil.

Next steps our research include: increasing of biomass using mineral fertilizers/growth regulator and monitor its effect on phytoextraction potential; development of methods for phytoreme¬diation of soils contaminated with pesticides based on the construction of plant-microbe combi¬nations.

In this experiment has been shown that the mineral fertilizers and growth regulator derivatives and their compositions with the wood charcoal and shungite increased biomass plants and reduced the concentration of pesticides in rhizosphere up to 57%.
From the rhizosphere of plants (Cucurbita pepo pumpkin, X.strumarium) four strains-destructors (Bacillus circulans, Rhodococcus erythreus, Pseudomonas aeruginosa and Bacillus sp.) has allocated. Strains-destructors are using to optimize environmental to increase remediation of the polluted soil by plants.

This information may be helpful in the development of technologies for phytoremediation of pesticide-contaminated soils.

Key words: soil. phytoremediation, organochloride pesticide, plant

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111. Nwaichi, Eucharia

Interdependence of soil and agricultural practice in a two – year phytoremediation in situ experiment

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A two - year plant – based soil clean – up was carried out at a crude oil spill agricultural site in a Niger Delta community in Nigeria to assess further clean - up potentials of Cymbopogon citratus. Applied diagnostic ratios identified mixed petrogenic and pyrogenic sources as the main contributors of PAHs. Up to 90.8% sequestration was obtained for Carcinogenic PAHs especially Benz [a] pyrene in a 2 – phase manner. A community-level approach for assessing patterns of sole carbon source utilization by mixed microbial samples was employed to differentiate spatial and temporal changes in the soil microbial communities. In relation to pollution, soil conditioner notably decreased the lag times and showed mixed effects for colour development rates, maximum absorbance and the overall community pattern. For rate and utilization of different carbon substrates in BIOLOG wells, after day 3, in comparison to control soil communities, contamination with hydrocarbons and associated types increased amines and amides consumption. Consumption of carbohydrates in all polluted and unamended regimes decreased markedly in comparison with those cultivated with C. citratus. We found a direct relationship between cellulose breakdown, measurable with β–glucosidse activity, organic matter content and CO2 release within all soils in the present study. Organic amendment rendered most studied contaminants unavailable for uptake in preference to inorganic fertilizer in both study years. Generally, phytoremediation improved significantly the microbial community activity and thus would promote ecosystem restoration in relation to most patronised techniques. Supplementation with required nutrients, in a long – term design would present many ecological benefits.
Keywords: Agricultural soil; Recovery; Hydrocarbon pollution; Ecology; Management practice

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112. Okoronkwo, Afamefuna Elvis

BANANA STALK DERIVED LIGNIN AS ADSORBENT FOR NICKEL (II) ION REMOVAL FROM WATER

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In this study, lignin was extracted from banana stalk and modified via amination. Both unmodified and modified lignin ere used as adsorbent materials in batch process removal of nickel (II) ion from aqueous solution. The adsorbents as well as the metal loaded lignin were characterized using the Fourier transform Infra-red spectroscopic analysis (FTIR). Adsorption parameters such the effects of pH, metal – adsorbent resident time, metal ion concentration, and adsorbent dosage were studied. The sorption of the metal ions was strongly pH dependent and maximum removal of the nickel ion from the solution was attained at pH of 9. The biosorption process was rapid and equilibrium was attended within 30min of interaction. Data obtained from the study of the removal process fitted well into the pseudo-second order kinetic model as well as obeyed the Freundlich isotherm model. The adsorption process was spontaneous and exothermic in nature. Modification of the lignin obtained via amination led to remarkable enhanced removal capability. Recovery of nickel (II) ion from the spent materials was accomplished using 0.1M HCl.

Keywords: Banana Stalk, Lignin, Sorption, Pseudo-second order, Amination

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114. Pan, Fengshan

Enhanced Cd-extraction of oilseed rape (Brassica napus) by plant growth promoting bacteria isolated from rhizosphere soil and roots of Sedum alfredii Hance

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Two heavy metal tolerant rhizosphere bacteria strains SrN1 (Arthrobacter sp.) and SrN9 (Bacillus altitudinis) as well as one heavy metal tolerant endophytic bacteria strain SaN1 (Bacillus megatherium) were isolated from rhizosphere soil and roots of the Cd/Zn hyperaccumulator Sedum alfredii Hance. Such bacteria are known to behave as plant growth promoting bacteria (PGPB) for Sedum alfredii. A pot experiment was carried out to investigate the capability of these PGPB to also enhance plant growth and Cd-accumulation rates in oilseed rape (Brassica napus) plants grown on aged Cd-spiked soil. Endophytic bacteria SaMR12 (Sphingomonas) were used as a positive control. The results showed that the four PGPB significantly boosted the oilseed rape shoot biomass production, enhanced Cd-uptake by the plant and Cd-translocation to the leaves. The endophytic bacteria performed better in this respect than the rhizosphere bacteria. The studied endophytic bacteria, isolated from Sedum alfredii, were able to colonize successfully in the Brassica napus roots as was demonstrated by fluorescent in situ hybridization (FISH). Due to its potential to enhance Cd-uptake by the plant and to restrict Cd-accumulation in the seeds, SaMR12 was identified as the most promising microbial partner of Brassica napus when setting up a plant-microbe fortified remediation system.

Keywords: oilseed rape (Brassica napus); Cd; plant growth promoting bacteria (PGPB); Sedum alfredii Hance; fluorescent in situ hybridization (FISH)

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115. Pavlowsky, Johanna

Assessing Downstream Benefits of Green Infrastructure Design and Planning on Urban Stormwater Runoff

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Urbanizing watersheds causes debilitating effects to downstream catchments and stream channels. The implementation of green infrastructure (GI), such as green roofs, permeable pavements and vegetated rain gardens, have shown to alleviate these effects by both reducing runoff and mitigating pollutants. Portions of Rolla as well as the S&T campus drain into the impaired urban waterbody, Schuman Lake. The lake is plagued with poor water quality, eutrophication, and a substantial fish kill in 2014. Water quality parameters, such as temperature and nitrogen and phosphorus concentrations, serve as good indicators of water quality due to their pertinence to algal growth. Since fall of 2014, traditional lab and field sampling and monitoring methods have been used to monitor stormwater runoff flows, volumes, temperatures, and corresponding TP, TN, and TOC loads at various points in the contributing drainage area of the urban wetpond. Novel remote sensing and citizen science tools are being developed to better assess urban water flows and pollutants. After an assessment of data observations and trends, evaluations of current vegetated GI implements in the drainage area, as well as recommendations for further GI design and implementation, will be presented.

Keywords: green infrastructure, urban stormwater, watershed monitoring, water quality

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116. Paz-Alberto, Annie Melinda

Assessing Diversity and Phytoremediation Potential of Mangroves for Copper Contaminated Sediments in Subic Bay, Philippines

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Toxic metal pollution of water and soil is a major environmental problem and most conventional remediation approaches may not provide adequate solutions. An alternative way of reducing Copper (Cu) concentration from contaminated sediments is through phytoremediation. Presently, there are a few research findings on the phytoremediation potential of mangroves on metals like Cu. The study was conducted to survey and identify mangroves present in Subic Bay, Philippines and to assess the phytoremediation potential of mangrove species on Cu in sediments. A total of five mangrove species were identified in the study area such as Barringtonia racemosa, Bruguiera sp, Canophyllum inophyllum, Rhizophora apiculata and Sonneratia alba. The Species Diversity Index of the mangroves in the area indicated low diversity due to low species richness and uneven distribution of different species in the study area. Nonetheless, mangrove species in our study area possessed the capacity to absorb Cu, potentially aiding in the retention of toxic materials and thereby reducing transport of Cu to adjacent estuarine and marine ecosystem. Sonneratia alba, Barringtonia racemosa, Bruguiera sp, and Rhizophora apiculata are potential phytoremediators of Cu from contaminated sediments in mangrove ecosystems.

Keywords: phytoremediation, mangroves, heavy metals, copper, sediments

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117. Pidlisnyuk, Valentina

Perennial phytotechnology for sustainable land management at the former military sites in Slovakia and Ukraine

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Implementing green remediation technologies that are also sustainable requires selection of appropriate technologies. Guideline documents have formulated suggested strategies. Combining phytoremediation technologies with production of biofuel crops looks attractive. This gives the possibility of restoring marginal land to agricultural food crop use or for urban land bank while simultaneously satisfying demand for biomass production as an alternative energy source. Miscanthus is considered among the most promising biofuel crops for that approach.
A long-term experiment with real soils from contaminated military sites in Slovakia (Sliach) and Ukraine (Kamenetz-Podilsky) is in progress. The contaminated soils in pot studies were diluted by comparable clean soils taken from neighboring places. The uptake of heavy metals: Cr, Mn, Zn, Pb and As from the soils into the plant's parts was monitored through the entire growing season. A laboratory pot experiment confirmed the ability of Miscanthus x giganteus to grow in the contaminated military soils. Results show only slight correlation between increasing concentrations of contaminants in the diluted soil and their uptake to the plant. The main increase of heavy metals in the above surface parts of the plants occurred at the beginning of the growing season and remained relatively stable till the end of the season. The amount of heavy metals uptake by above surface plant parts was not and was mainly under the regulatory limit levels.

Keywords: military contaminated soils, miscanthus x gigantheus, heavy metals, dynamics of uptake, Slovakia and Ukraine

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118. Pierattini, Erika

Populus alba uptake and metabolism of Pharmaceuticals and Personal Care Products

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Pharmaceuticals and personal care products (PPCPs) have recently become issues of increasing concern due to their widespread use and continuous release into the aquatic environment. Moreover, many PPCPs cannot be efficiently eliminated by conventional wastewater treatment plants. Phytoremediation is one of the most promising "green" techniques since it is effective and low-cost; in fact, plants have the capability to absorb, translocate, and metabolize organic xenobiotics such as PPCPs.

We tested the well-known phytoremediation capabilities of poplar (Populus alba Villafranca clone L.) with two of the most common PPCPs, caffeine and erythromycin. Both compounds have been demonstrated not to undergo photodegradation nor biodegradation processes. Caffeine persistence in the aquatic environment damages micro fauna, while persistence of erythromycin could lead to an arise in bacterial resistance to this antibiotic.

We investigated the uptake of caffeine-(trimethyl-13C) and its degradation in theobromine-(dimethyl-13C) and theophylline-(dimethyl-13C) in roots, stem and leaves of poplar plant grown in hydroponic conditions, using LC-MS/MS analyses. The use of caffeine-(trimethyl-13C) allowed us to discriminate the exogenous caffeine and its metabolites from the endogenous ones. We observed that the concentrations of endogenous compounds vary in consequence of caffeine-(trimethyl-13C) treatment (2 mg L-1) in all plant organs. Erythromycin uptake was evaluated through a screening of concentrations (0, 0.01, 0.1 and 1 mg L-1). For both compounds Populus alba did not show negative symptoms, confirming its potential for phytoremediation purposes.

Keywords: caffeine, erythromycin, poplar, LC-MS/MS.
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119. Pilon-Smits, Elizabeth

Evolution of Selenium Hyperaccumulation in Stanleya

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Stanleya pinnata (Brassicaceae) accumulates up to 0.5% of its dry weight in selenium (Se), probably as a defense mechanism against herbivores. We are interested in the evolution of Se hyperaccumulation and hypertolerance in Stanleya, and the evolutionary mechanisms that gave rise to these traits. A genus-wide survey was done on all Stanleya species and varieties, for leaf and fruit Se levels in the field and in a common garden experiment, as well as Se localization and speciation (using x-ray microprobe analysis). These Se-related data were mapped onto a phylogenetic tree that was created from molecular data. Selenium hyperaccumulation was found to be a derived trait unique to two S. pinnata varieties (var. pinnata and bipinnata). Hypertolerance to Se was found in more taxa and may be an older trait.

A particularly interesting trait in Stanleya pinnata is that it can distinguish selenate from sulfate: it preferentially takes up selenate over sulfate and is not inhibited by high S levels. A goal for further study is to identify the responsible selenate transporter and functionally analyze it to obtain insight into the molecular mechanism. This would be very interesting for Se phytoremediation and biofortification, because Se and S often co-occur and Se uptake is hampered by high S levels. Comparison of gene expression levels between S. pinnata and S. elata and B. juncea point to Sultr1;2, encoding a high affinity sulfate/selenate transporter, which is much more highly expressed in S. pinnata. Stanleya is also different from other species in that it accumulates its Se mainly as the aminoacid methyl-selenocysteine. This capacity to convert selenate to organic Se likely contributes to its Se hypertolerance. A key enzyme for selenate assimilation, ATP sulfurylase 2 (aps2), was constitutively expressed at extremely high levels in S. pinnata. The Sultr1;2 and APS2 genes were cloned from S. pinnata and S. elata and the sequences compared, which revealed some interesting differences. Both genes will be functionally characterized via expression in yeast and Arabidopsis.

Keywords: selenium, hyperaccumulation, mechanisms, phytoremediation, biofortification

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121. Placek, Agineszka

The use of forest phytotechnologies to remediation of heavy metals polluted soil amended with sewage sludge

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Forest species are among the most commonly used plants in phytoremediation process of degraded and devastated areas. The object of research was to indicate the efficiency of improving the quality of heavy metals contaminated soil by use three tree species during phytoremediation process carried out in the field conditions. In the five-year study sewage sludge from the food industry has been used as an additive to the soil supporting the phytoremediation process of degraded land. The application of sewage sludge causes an increase in cation exchange capacity, and thus stronger binding of cations in the soil environment, which involves the immobilization of nutrients and greater resistance to contamination.
The field experiment was established in 2010. Over the five years samples of plant material were collected twice a year (spring and autumn). The field experiment was carried out at a near distance of the zinc smelter. The soil on degraded area is poor in nutrients, is distinguished by a low pH and sorption capacity, and is characterized by high accumulation of heavy metals. In order to perform the planned field trials experiments, two research plots were formed. On the first plot the sewage sludge from the food industry was applied. In contrast, the second plot was used as a control for the first plot, without the sewage sludge application. For both research plots the three species of plants were planted: Scots pine (Pinus silvestris L.), Norway spruce (Picea abies) and oak (Quercus robur L.). On the plot fertilized with sewage sludge, the proper growth of plants and large increase in biomass of trees were noted. Sewage sludge used in this experiment is of considerable importance in the phytoremediation process of soils contaminated with heavy metals (Cd, Zn and Pb). The conducted field experiment demonstrated that selected trees like Scots pine and Norway spruce, because of its excellent adaptability, can be used in the remediation of soil and of soilless devastated areas, such as pioneering plants.

Keywords: degraded soil, heavy metal, forest phytotechnologies, soil amendments, sewage sludge

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122. Prusty, B. Anjan Kumar

Heavy metal accumulation and translocation in soil-plant interface in wetland-cum-agricultural ecosystems around Keoladeo National Park, India: Implications on ecological processes and human health

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Contamination of heavy metals is found to have major impacts on the environment and it threatens the ecosystem's stability. Increasing use of chemical pesticides and fertilisers in farmlands along with other anthropogenic activities is known to result in elevated levels of heavy metals in soil and water worldwide which has resulted in serious environment deterioration. The mobility of these metals further leads to their transportation along different trophic levels in a food chain and tend to accumulate in various plant tissues depending upon the species physiology, metal properties and bio availability in the environment. Since, many of the heavy metals are known for their toxic effects on the living systems including human beings, we undertook a study to examine the extent of bio-accumulation of Fe, Ni, Zn, Mn, Cu and Co in certain crop species grown in wetlands cum farm lands around Keoladeo National Park (KNP), Rajasthan, India. In total, 15 locations were covered in the study, wherein surface soil samples were collected, and crop samples were uprooted so that both below ground and aboveground parts of the plants could be collected. Four (crop) plant species namely, Triticum spp., Pennisetum glaucum, Brassica sp. and Sorghum bicolor were collected from wetland-cum-farmland areas viz. Babula, Bhatawali, Goverdhan Drain, Hingonia, Kalakoh, Panchana, Chandlai, Bandh Baretha, Nonera, Ajan Dam, Bhandore, Rupbas, Motijheel, Jagartal, Nonera (wheat field) around KNP, Rajasthan, India. 15 composite (of three replicates) soil samples and plants samples (segregated into roots, stems, leaves and grain) were processed and digested following mixed acid digestion methods. Total concentration of Fe, Ni, Zn, Mn, Cu and Co in soil and plant samples were measured using a double beam Atomic Absorption Spectrometer (AAS, Perkin Elmer, AAnalyst 800). Bio concentration factor (BCF, metal concentration ratio of plant roots to soil), translocation factor (TF, metal concentration ratio of plant shoots or leaves to roots), and Bio accumulation coefficient (BAC, metal concentration ratio of plant shoot to soil) were estimated that provided insights into the levels of mobility of selected metals in the wetland/farmland systems, as well as the accumulation pattern in plants. This paper will further discuss the correlation amongst the metal uptake by plants. A bio-concentration and translocation factor having value greater than 1 will indicate high uptake by plant tissues concluding that these crop plants are not suitable for human consumption as they will be having toxic effects on the ecosystem. This paper while discussing the ecological issues related with metal accumulation in plants (hyper accumulators etc.) will also throw light upon the issues on human consumption of such crops and their parts.

Key Words: Bioaccumulation, bio-concentration factor, heavy metals, transportation index, wetlands

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123. Rao, Muralidhar C.

Evaluation of Pteris vittata (break fern),a native plant for remediation of residual Uranium from mine tailings

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Safe disposal of uraninium mine tailings during the process of mining has been a matter of cencernwith increasing quantum of tailings and growing trend of natural uranium mining. Thogh scintific landfilling is practiced presently,phytotechnology ccould provide cleaner and cheaper solution to this problem. Among the 23 odd native plants screend for sequestration of resedual uranium from the vicinity of uranium mine tailing disposal site in India, Pteris vittata (break fern) was found to be most effective and holding highest promise with a potential of accumulating upto 4.00 ppm of uranium in it's biomass. The plants abundance of occurance ,non-browsability and easiness to grow and harvest makes it all the morea potential candidate for phytoremediation of uranium. Seqestration potential of the plant was confirmed (upto 2.82 ppm) by raising it in pots containg tailing s media in diffeerent concentrations in green house away from the dumping site. The results were consitant.

Key words: sequestration,uranium,mine tailings,phytremediation.break fern

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124. Razaque, Memon Abdul

Metal hyper-accumulators: Mechanisms of hyper-accumulation and metal tolerance

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A number of regulatory mechanisms have been developed by metal hyper accumulator plants for their survival in metal polluted environment. In the last decade, with the development of advanced technologies most of the information about heavy metal stress in plants has been obtained through genome sequence, transcriptome, metabolome, and proteome studies. For example, through such techniques, it has been possible to identify numerous putative genes involved in the response to metal stress. A number of membrane transporter gene families have been found in accumulator plants such as ZIP, NRAMP, YSL, NAS, SAMS, FER, CDF, HMA and IREG families which are predicted to be involved in the cellular uptake and transport in plants. HMAs (heavy metal ATPases) are particularly interesting and many recent studies have been shown their key role in metal hyperaccumulation in plants. In this regard we have analyzed the gene expression data of model crop plants in Brassicaceae family by searching several databases available online. The criterion observed in this research is that the sequences of different metal induced genes have functional and evolutionary similarities among species. Our hypothesis is that the functionally related sequences of the genes from different species or organisms will be having conserved pattern or motif which will be possibly related to hyperaccumulation of heavy metals. Here, I will overview these findings and highlight their contribution to the field of plant metal homeostasis, and will discuss the emerging avenues of omics technologies and their impact in understanding the mechanisms of metal accumulation and tolerance.

Keywords: Metal accumulators, metal transporters, heavy metal ATPases (HMAs), phylogenetic analysis, micRNAs

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125. Rezaee, Arefeh

Phytomining of Light Rare Earth Elements

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Phytomining is the accumulation of bioavailable metals in the plant biomass for commercial achievement in a natural manner. Phytomining has recently received a great deal of attention since conventional metallurgical techniques may not suitable for reasonable metal recovery from low-grade ores such as rare earth element ores. Concentration of Rare Earth Elements (REE) in some ores are not high enough to be exploited by traditional method; thus, phytomining can be considered as a potential mineral processing technology for recovery of these elements. In this technique identification of appropriate plant species is considered as the first step for assessment of the technical viability of the phytomining operation. Plants should be able to hyperaccumulate target metals and the condition of location, where the metals are found, should be suitable for the plants to growth. In this project, the ability of different known metal hyperaccumulators are examined in a laboratory setting under climate controlled, and sterilized conditions. The seeds and spores of mentioned plants are grown in nutrient rich media with known rare earth element dosages. Lanthanum, cerium, and praseodymium that are known as light rare elements are the target metals in this work. Plants, after reaching the maturation stage are harvested, and divided into root, stem and leaves. The concentration of the metals in plants tissue will be determined by inductively coupled plasma mass spectrometry.

Key Words: Phytomining, hyperaccumulators, Rare Earth Elements, low grade ore, inductively coupled plasma mass spectrometry

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126. Rylott, Elizabeth L.

Field trials of genetically modified switchgrass to Remediate explosives pollution

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Containment and remediation of the explosive compounds hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and 2,4,6-trinitrotoluene (TNT) on military ranges are of high priority to the US Department of Defense. Plants have inherently low abilities to degrade or detoxify these environmental pollutants, and while soil microorganisms with activities towards these compounds exist in the soil, the accumulating pollution indicates that their presence is insufficient to remediate the problem. RDX is highly mobile in ground water and a significant threat to drinking sources such as those close to the US Massachusetts Military Reservation. TNT remains tightly bound to the soil organic material, hindering the use of plant-based approaches for remediation. Currently, there are no cost effective processes to contain RDX or remediate these vast areas of contaminated land.
From Rhodococcus rhodochrous 11Y, a unique bacterial cytochrome P450, XplA and its partnering reductase, XplB have been cloned [1]. When expressed in plants, XplA and XplB confer the ability to remove, and degrade, saturating concentrations of RDX from soil leachate. From Enterobacter cloacae, the nfsI gene encodes a bacterial nitroreductase than enables the plant to withstand, and detoxify, significantly higher concentrations of TNT than unmodified plants [2]. We have transformed switchgrass (Panicum virgatum), a species native to temperate military training ranges in the US, to express these explosive-detoxifying genes. Field trials are now underway to test the ability of transgenic switchgrass plants to remediate concentrations of RDX and TNT on military training ranges.

Keywords: RDX, TNT, explosives, genetically modified, phytoremediation

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[2] Hannink et al. Nat.Biotechnol. 19, 1168-1172.

127. Saba, Beenish

Antioxidant behavior in Hydrocotyle vulgaris under hydrocarbon stress in constructed wetlands

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Constructed wetlands (CW) are engineered bio-systems for treatment of organic contaminants. It is a phytoremediation technology for removal of contaminants. However, during contaminant removal plant responses under chemical stress are poorly understood. Plant releases antioxidant chemical species to deal with external stresses. In the present study, antioxidants concentration was evaluated under pyrene stress. Hydrocotyle vulgaris, a wetland plant was planted in pyrene spiked constructed wetlands. Serratia odorifera a growth promoting rhizobacterium was inoculated in wetlands to tolerate chemical stress and promote plant growth. Pyrene concentration in effluent, and chemical oxygen demand (COD) were monitored during treatment process. Presence of growth promoting rhizobacterium reduces plant stress and improved antioxidant concentration. Antioxidant enzyme activity trend was root>shoot>leaf. Plant peroxidase activity (POD) was 92% SPC (soil+plant+contaminant) higher than control SC(soil+contaminant) in first 7 days in roots and it was increasing with passage of time, while in shoot it was 68% and leaf 31%. Plant catalase, ascorbate peroxidase and lipid peroxidase also showed similar trends of result. This study confirmed that plant enzyme activity was higher under contaminant stress. Presence of microbes in rhizosphere assist plants in growth by reducing plant antioxidant stress.

Key words: Constructed wetlands, phytoremediation, growth promoting rhizobacterium

128. Saber, Mohamed

Phytoremediation of Potential Toxic Elements in Contaminated Sewaged Soils by Sunflower (Helianthus annuus) and Corn (Zea mays L.) plants

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At the time being, treated sewage effluent is repeatedly used in farming, particularly in newly reclaimed sandy soils, as it fortify their content of nutrients and organic matter as time goes on, despite there are significant concerns about the long-term accumulation of PTEs in the soil ecosystem. In a completely randomized pot experiment design in the greenhouse at the National Research Centre, Egypt, the two hyper-accumulator summer plants corn (Zea mays L.) and sunflower (Helianthus annuus L.) were tested to phytoremediate PTEs in the presence and absence of Arbuscular Mycorrhyzal (AM) inoculation from high and marginal contaminated sewaged soils. The results indicated that no sign of inhibition was noticed in the germination percent of both corn or sunflower plants and their growth habitat was customary without any obvious symptoms of PTEs toxicity in the two tested high and marginal contaminated sewaged soils. Inoculation with MA increased seed yield of corn and sunflower under both marginal (82.2 and 33.2%) and highly (43.3 and 17.6%) contaminated sewaged soils conditions. Inoculation with AM enhanced corn plant absorption of Zn and Cu to a degree that they contained two or three folds of Zn and Cu contents in control cultivated soil, in both contaminated sewaged soils. Root and shoot tissues of sunflower plants contained more Zn compared to those of corn plants grown in the same soil in the presence and absence of AM inoculation. Inoculation with AM in the high contaminated sewaged soils caused higher depression in Cu content in the roots and shoots reaching 31.4% and 64.3%, respectively. On the basis of the individual decontamination rate of each of the studied PTEs and Zn equivalent values, the cleaning potency of corm plant far exceeded that of sunflower plants for Zn, Cu as well as Ni. According to the numerical values of b factor corn exhibited a distinguished superiority to uptake PTEs from the studied contaminated sewaged soil ecosystem compared to sunflower and hence it is recommended under the specific conditions of sewaged soils. It was noticed, the phytoremediation process was more effective in minimizing the hazards of PTEs in the high contaminated sewaged soil.

Key words: Zn equivalent, sunflower, corn, phytoremediation, AM, sewaged soils

129. Saber, Mohamed

Valuation of certain remediative amendments in enhancing phytoremediation in various contaminated soil ecosystems

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After building of Grand Ethiopian Renaissance Dam (GERD), significant drastic shortage in Nile water resources in Egypt is predictable. This situation of water shortage would force Egyptian farmers to use low quality water resources impregnated with a variety of contaminants that will inserted in food chain. In a complete randomized plot design greenhouse experiment, soil samples collected from Abou-Rawash, Sinai and Kafr El-Shekh Governorated irrigated with varied types of low quality waters for extended periods were trailed for the sake of valuation of new innovative phytoremediation practices. In the used three soil ecosystems, the Zn equivalent parameter, that indicates the safety of cultivation, ranged between 340 and 630, while the safe level should not exceed 250. Integrated management practices were applied using canola and Indian mustard hyper accumulator plants, in association with Acidithiobacillus thiooxidans and Arbuscular Mycorrhiza (AM) after furnishing the soil ecosystem with the chemical stabilizer of PTE's probentonite. Results indicated that the canola hyper accumulator plant was more efficient than Indian mustard plant especially in Ni uptake compared to Cu or Zn uptakes. In addition, the introduction of Acidithiobacillus thiooxidans and AM to the contaminated soil ecosystems significantly enhanced the uptake of PTE's. The kinetic parameters of both theoretical and empirical models confirmed that the mixture of all remediative amendments was the best in minimizing Zn equivalent value to a save level. The different mechanisms that might take place between the applied remediative amendments and PTE's in the three contaminated soil ecosystems were discussed.

Key words: Zn equivalent, Kinetic models, PTE's, Soil ecosystems, Sewage effluents, Acidithiobacillus, Mycorrhiza.

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130. Saber, Mohamed

Prolonged effects of irrigation with low quality water on soil biological characteristics

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Surface soil samples irrigated with low quality water, i.e., agricultural drainage water or treated sewage effluent for prolonged time between > 35 to > 85 years `as well a control alluvial soil irrigated with Nile were collected. The microbiological characteristics of these soils were compared with the microbiological characters of a soil irrigated with Nile water collected from Tanash village. Results showed the microbial biomass represented by bacteria, fungi and Azotobacter was in general more or less the same in the different investigated soils. On the other hand, the new indicators of pathogenic bacteria (Pseudomonas) exhibited positive existence even in the soil irrigated with Nile. Data showed that the most important parameter indicating the bioactivity of a certain soil ecosystem, i.e., dehydrogenase activity was highest in soils irrigated with sewage effluents from either Abu-Rawash or Zeneen sewer plants being even higher than in the soil irrigated with Nile.

Key Words: Low quality water, Aquatic microorganisms, Dehydrogenase, Soil irrigated with sewage

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131. Saeed, Rasheed

Alternanthera bettzickiana a halophytic plant for phytoremediation of Cadmium (Cd), Chromium (Cr) and Lead (Pb) contaminated soils

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Phytoremediation is a vital and inexpensive technique used to remediate soils heavily contaminated with heavy metal from textile effluents, tannery waste and other anthropogenic sources. Plants that show high metal accumulation often show slow growth rate and little biomass production when grown on soils contaminated with metals. Exploration and cultivation of heavy metal halophytic tolerant plants with a better growth is a very effective method for the purpose of phytoremediation of different mediums contaminated with heavy metals. In this investigation, varying physiological and biochemical attributes of ornamental plant Alternanthera bettzickiana due to its tolerance to high salinity levels as reported in literature. So, keeping in view the resistance of this plant against high salinity levels, the present experiment was performed to find out the potential of A. bettzickiana to different regimes of cadmium (Cd), chromium (Cr) and lead (Pb) maintained in soil. Different levels of cadmium (Cd), chromium (Cr) and lead (Pb) treatments (0 mM, 0.5 mM, 1 mM and 2 mM) were applied in solution form after the establishment of the cuttings. $CdCl_2$,, $K_2Cr_2O_7$ and $Pb(NO_3)_2$ were applied as a source of Cd, Cr and Pb. For the estimation of varying physiological and biochemical attributes the plants were harvested after 10 weeks of planting the plant stem cuttings. Potassium sulfate (K_2SO_4), urea (CH_4N_2O) and diammonium phosphate [$(NH_4)_2HPO_4$] were used as fertilizers @ 2.19:1.36:2.4 mgL -1 after every 15 days to maintain the NPK ratio in the soil. Plant height and biomass increased significantly with the application of Cd, Cr and Pb stress and the maximum gain in biomass was obtained when Cd and Pb was applied @ 1 mM concentration. No visual symptoms of metal toxicity were observed on plants leaves or roots at all Cd and Pb regimes but Cr has negatively affet plant growth at all Cr levels. Of different enzymatic antioxidants, superoxide dismutase (SOD), catalase (CAT) and peroxidase (POD) activities were also affected significantly increased in Cd, Cr and Pb treated plants. Furthermore, soil Cd, Cr and Pb application increased its internal content in both the roots and leaves and the maximum metal content was in plants treated with 2mM Cd, Pb and Cr level. From the results it was concluded that A. bettzickiana plants accumulated high concentrations of Cd when grown under Cd, Pb and Cr stress and showed tolerance mechanism against these levels. Thus we can conclude that A. bettzickiana seems to be valuable for phytostabilisation strategies.

Key Words: A. bettzickiana, Antioxidants, Halophytes, Heavy Metals, Phytoremediation

132. Samarakkody, Ruwani

Removal of Cd(II) from contaminated soils and treatment of effluent using Nephrolepis exaltata

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The industrial revolution has resulted usage of various chemicals for industrial productions and generation of pollutants. When enhance the socio economic status of the country by improving chemically synthesized methodologies, it automatically contributes to environmental pollution and hazardous to living organisms. Industrial waste water in metal plating facilities, fertilizers, pesticides and textile industries are some of practices that contribute to environmental pollution. Some of this industries release excess level of Cd(II) into surround. Currently available engineering waste water treatment and soil remediation methods for Cd(II) are very costly. Phytoremediation and biosorption are the promising strategies for remediate the contaminated sites in an environmentally friendly and economically viable way. On this matter a study was conducted to investigate the potential of Cd(II) removal from soil and effluent using Nephrolepis exaltata. A pot experiment was conducted to assess the potential of phytoextraction of Cd(II) by Nephrolepis exaltata. The screening test was implemented using Nephrolepis exaltata leaflet as sorbent to remediate Cd(II) contaminated water under laboratory condition the ability of the fern to accumulate Cd(II) in leaflets, stem and roots was studied during two weeks period by treating the soils with three different concentrations of Cd(II) as 3.0, 5.0 and 7.0 mg kg-1 one week after transplant of fern. The maximum Cd(II) accumulation in roots (12.66±0.67 µg g-1 of dry weight) was recorded from 7.0 mg kg-1 Cd(II) treated soil. The citric acid is one of naturally available chelating agents (each at 0.5and0.1 mmol kg-1 of soil) was applied to determine the efficiency of Cd(II) removal from 3.0 mg kg-1of Cd(II) contaminated soil. The results revealed that, N. Exaltata grown insoil treated with 0.5 mmol kg-1 of citric acid could be effectively absorbed Cd(II) than the non citric acid treatments. The maximum Cd(II) absorption (3.33±0.38 µg g-1 of dry weight) was recorded in leaflets of the plants grown in soil treated with 0.5 mmol kg-1 ofcitric acid. Dried biomass of N. Exaltata was used to investigate the capacity Cd(II) biosorption from synthetic eluent. Eluent of 1.0 µg L-1Cd(II) was adsorbed up to 96.06 ± 0.02 % by 1 g L-1 of prepared biosorbent (particle size 250 – 350 µm) in 4.50 to 5.50 pHrange during a shaking time of 45 to 60 minutes in a batch sorption system. The result concluded Nephrolepis exaltata has a potential to remove Cd(II) by contaminated soil and effluent.

Keywords;
Phytoextraction,Waste Water Treatment, Cadmium (II), Chelates, Nephrolepis Exaltata

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133. Sarangi, Bijaya Ketan

Designing arsenic phytoremediation system: significance of arsenate reductase evolution in arsenic tolerant biological systems

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Arsenic(As) phytoextraction through hyperaccumulator plants are of special importance for biological remediation. Phytoremediation performance of a biological organism depends on its response to As toxicity and the intensity of severity which significantly varies amongst them. Conversion of As(III) As(V) is crucial for detoxification, tolerance, exclusion and accumulation in organisms. The chemistry of conversion of As(V) to As(III) through arsenate reductase (AR), and genetic makeup conferring the mechanism has evolved through different prokaryotic and eukaryotic organisms: the arsC cistron of the ars operon from both gram-positive and gram-negative bacteria from (Staphylococcus aureus, Escherechia coli, Bacillus subtilis, Pseudomonas and other species); ACR2 gene (referred as ScACR2) from Saccharomyces cerevisiae, CDC25 phosphatase/ACR2 arsenate reductases from Arabidopsis thaliana and PvACR2 from Pteris vittata. In animal and other biological systems, As(III) is methylated and excreted out of the system, conversely it is compartmentalized in As tolerant bacteria, plants and hyperaccumulator P. vittata. Strategically design phytoremediation system should include As hyperaccumulator plants in association with compatible other organism and appropriate soil water management with respect to site specificity. Better understanding evolution of the arsenate reduction trait is essential for formulation of plant-microbe-plant consortia that could enhance phytoremediation through synergistic action. Arsenate reductase protein sequences from five different As tolerant biological species were analysed using bioinformatics tools to understand AR evolution amongst them, and develop biomarkers to identify other such potential biological systems. Phytoremediation needs to be strategically designed through appropriate plant-soil-plant-microbe association using such knowledge, and geophysical conditions to get technology status.

Key words: Phytoextraction, arsC – ars operon, ACR, ScACR2, PvACR2, hyperaccumulator plant

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134. Sarkar, Supriya

Attenuation of chromium toxicity in mines waste water by Eichhornia crassipes

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The waste water at Sukinda chromite mining area of Orissa (India) showed high levels of toxic hexavalent chromium (Cr+6). Cr+6 contaminated mine waste water having potential threats for biotic community in the vicinity.The aim of the present investigation is to develop a suitable phytoremediation technology for the procumbent removal of chromium from mines wastewater. A water hyacinth speciesEichhornia. crassipes was chosen to remediate chromium from waste water. It has been observed that plants were able to removed 99.5% Cr+6from the Sukinda chromite mines (SCM) processed water in 15 days. It not only removedhexavalent Cr, capable to reduce TDS, BOD, COD and other elements of water also.

Key words: Phytoremediation, chromium, water hyacinth, Sukinda chromite mines.

135. Scholes, Chad

Use of Vegetation Sampling and Analysis to Detect a Problem Within a Portion of a Restored Prairie at the DOE Weldon Spring Site

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In June 2002, the Department of Energy (DOE) established the 150 acre Howell Prairie around the disposal cell at the DOE Weldon Spring Site (WSS). The prairie was established to revegetate an area of the site to a condition similar to that of prairies that were historically present in the area, and to provide a vegetative soil cover for erosion protection. The history of land restoration work is plagued by a lack of documentation of success. The number of samples required and precision achieved were determined by sample size equations that protected for both Type I and Type II error. Vegetation analysis in 2008 included tests to determine the most appropriate transect length and quadrat size. Four permanent vegetation sampling plots were established. Cover sampling was broken into native grasses, native herbs, exotic grasses, exotic herbs, litter and bare ground. The first four years of vegetation measurements at Howell Prairie were made during above average rainfall years on burned and unburned plots. The fifth year (2012) vegetation measurements were made during one of the worst single season droughts on record for the area. Five years of vegetation sampling and analysis at Howell prairie demonstrate not only the efficacy of the measurements, but the value of documenting the success of revegetation over time. The results not only document the consistency of the restoration effort in three areas, but demonstrate deficiencies in native species cover in a fourth area. The results are not only useful for Howell Prairie, but will be useful for restoration work throughout the region.

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136. Schroer, Hunter

Fate and Metabolism of 2,4-Dinitroanisole in Willow Trees

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The environmental fate of 2,4-dinitroanisole (DNAN), a component of new insensitive munitions explosives (IMX), is an emergent global issue. The new IMX formulations are replacing old formulations at a rapid pace, but the environmental fate and ecosystem toxicity of IMX components remains largely unknown. DNAN and other nitroaromatics have been shown to cause harm to human health and ecosystems which makes widespread use of DNAN concerning. Full-scale remediation will be necessary for military testing sites and ammunitions manufacturing plants around the world as more countries adopt the new IMX formulations. Therefore, knowledge regarding the fate of DNAN within natural systems is needed to support future phytoremediation efforts resulting from inevitable IMX waste discharges.

The research presented is what we believe to be the first comprehensive study of 2,4-dinitroanisole metabolism in a plant system. Data will be shared on the fate of DNAN in willow trees, including bulk partitioning to roots, stems and leaves resulting from 14C-labeled DNAN studies. Furthermore, the metabolic fate of DNAN was determined using 13C-DNAN and 15N-DNAN stable isotope analysis. Similar to other studies on biological systems, metabolites such as 2-amino-4-nitroanisole and 2,4-diaminoanisole have been confirmed in willow and other metabolites are being confirmed. A full metabolic profile and suspected pathways will be presented. Implications for the environment and full-scale phytoremediation will be offered.

Keywords: insensitive munitions explosives (IMX), 2,4-dinitroanisole (DNAN), willow trees, phytoremediation, metabolomics

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1Civil and Environmental Engineering
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137. Servin, Alia D.

Nanoscale Interactions between Engineered Nanomaterials and Black Carbon (Biochar) in Soil

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The increasing manufacturing and use of engineered nanomaterials (NMs) has resulted in potentially excessive yet poorly characterized environmental exposure. NMs that have been released into these environments will interact with soil constituents, including black carbon (BC), which may subsequently affect particle fate and toxicity to soil-based biota such as plant and earthworm species. Studies have initiated using biochar from several different feedstocks and synthesis conditions. These were added separately to an agricultural and residential soil at three amendment rates of 0, 0.5 and 5% (v/v). Cerium oxide (CeO2) nanoparticle solutions were added to pots to yield final concentrations of 0-2000 mg/kg. At harvest, plants grown in residential and agricultural soil had a decrease in pigment content/production upon CeO2 NPs. In addition, biochar added to residential and agricultural soil had a little effect on Ce uptake and translocation by all treated plant species. Moreover, moisture content of plants grown in residential soil decreased upon the highest CeO2 NPs concentrations. After 48 h of depuration, lyophilized earthworms were analyzed using synchrotron µ-XRF, µ-XANES and spectroscopic techniques. Results showed that earthworms added to residential soil had an increase in Ce accumulation at the 1000 mg CeO2 NPs kg-1 treatment and a decrease in moisture content upon CeO2 NPs, while earthworms in agricultural soil had no significant effects. µ-XRF and µ-XANES analysis confirmed the accumulation of Ce in sample tissue. Images from earthworm's cross-sections at 1000 CeO2 mg/kg and 5% biochar treatment corroborated the presence of Ce in the digestive track system of the worms. While the µ-XANES results showed that the Ce inside worm tissue remained as CeO2.

Keywords- Engineered Nanomaterials, Biochar, Nanotoxicology

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138. Seth, C.S.

Chelate assisted chromium uptake, translocation and toxicity amelioration in Indian mustard (Brassica juncea L. cv. Varuna)

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Indian mustard (Brassica juncea L. cv. Varuna) when exposed to various concentrations of chromium and oxalic acid (0, 6.25, 12.5, 25 mg/250 gm of soil) in 1:1 for 42 days, exhibited specific phytotoxic and tolerance responses in dose dependent manner. The results revealed the highest amount of Cr (VI) accumulation in roots (8.16 and 12.38 mg kg-1 DW) and shoots (1.84 and 8.36 mg kg-1 DW) for exposure of Cr (VI) alone and Cr (VI)+OA, respectively. These findings are suggesting that oxalic acid promotes Cr (VI) uptake and translocation more efficiently, which is a prime requirement for success of phytoextraction. The toxic effect and oxidative stress caused by Cr (VI) were evident by lowering in biomass, photosynthetic pigments, gas exchange attributes and increase in malondialdehyde contents. Morphological symptoms of senescence phenomena such as chlorosis and fragmentation of leaves were also observed. The metal tolerance and detoxification strategy adopted by plants were investigated by antioxidant defence system and phytochelatins. Enzymatic (superoxide dismutase, guaiacol peroxidase, ascorbate peroxidase, catalase and glutathione reductase), non enzymatic (cysteine, non-protein thiols, glutathione) antioxidants and phytochelatins showed significant ($p<0.05$) higher activity followed by decline at 25 mg of exposure. The plants had achieved a good level of tolerance against Cr (VI) evident by significant ($p<0.05$) synthesis of many antioxidants, primarily glutathione (2.099 µmol g-1 FW) and phytochelatins (0.625 µmol g-1 FW) @ 25 mg of Cr exposure. All the aforesaid results showed a clear pattern of ameliorating toxicity and enhancement of Cr (VI) uptake and translocation once applied the oxalic acids; confirmed by gas exchange responses (A- 6.54 µmol m-2sec-1, E- 5.49 mmol m-2sec-1, GH2O- 335.1 mmol m-2sec-1, WUE- 1.191, TR- 0.84 against 25.0 mg of Cr (VI)+OA exposure). Present findings suggested that Indian mustard could be used as a potential remediator of Cr (VI) under application of oxalic acid.

Keywords: Chromium, oxalic acid, glutathione, phytochelatins, gas exchange analysis

139. Shabnam, Nisha

Impact of ionic and nanoparticle speciation states of silver on photosynthesis in Spirodela polyrhiza

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Nanoscience, a rapidly advancing area of science, has touched every sphere of life. Unique physicochemical properties enable metal nanoparticles find applications in innumerable sectors of engineering including aerospace and defence; medicine; agriculture; environment. It is imperative to evaluate impact of ionic and nanoparticle speciation states of concerned metals. Findings presented here are outcome of investigations carried to evaluate impact of ionic and nanoparticle speciation states of silver on key metabolic processes i.e. photosynthesis in aquatic plant, Spirodela polyrhiza. In general, overall photosystem II efficiency (measured as ratio of variable to maximal Chl a fluorescence, Fv/Fm) decreased significantly in S. polyrhiza exposed to both ionic and nanoparticle speciation states of silver, albeit Ag-NPs induced decrease was significantly lower than that caused by Ag+. Accordingly, decline in amplitude of fluorescence of Chl a fluorescence (OJIP) transients brought about by Ag+ was significantly higher than that recorded with Ag-NPs. Phenomenological yield models, built using Biolyzer software HP3 from biophysical expressions derived from original Chl a fluorescence transients using JIP test, revealed that the potential of leaves exposed to Ag+ to trap and harness absorbed light energy for photochemical reactions was significantly lower than those exposed to Ag-NPs. Accordingly, dissipation of absorbed light energy in form of thermal energy was significantly higher in leaves exposed to Ag+ than those exposed to Ag-NPs. These investigations revealed that although both ionic and nanoparticle speciation states of silver are toxic to aquatic plants, nanoparticle speciation state is less toxic compared to ionic speciation state.

Keywords: Spirodela polyrhiza, ionic speciation state, Ag-NPs, Fv/Fm, Chl a fluorescence transient

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140. Shahbaz, Muhammed

Cu-miRNAs target mimics as tools in bio-engineering of metabolism: A case study of comprehensive analysis of Cu homeostasis in plants

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Micro-RNAs (miRNAs) are small RNA molecules that play a role in gene regulation in plants as well as in animals. Every miRNAs is specific for one or more mRNA targets. In plants, target mimicry of miRNAs is a mechanism to negatively regulate the activity of a specific miRNA through the production of a false target transcript. This phenomenon can be exploited in synthetic biology approaches. Copper (Cu) is a cofactor for several enzymes in living organisms. During Cu limitation in plants, four specific microRNAs known collectively as the Cu-miRNAs, down regulate the expression of mRNAs that encode for of a wide variety of Cu proteins. It has been proposed that this regulatory circuit could help plants that experience Cu deficiency to maintain the most essential Cu proteins for photosynthetic electron transport (plastocyanin) and respiration (cytochrome c oxidase). In order to assess the importance of this regulatory mechanism for plant productivity under Cu deprivation, we designed a novel target mimic construct for all 4 Cu-miRNAs (miRNA 397, 398, 408 and 1444) and transformed both poplar and Arabidopsis. Analyses of target mimic-expressing plants showed that the Cu-miRNAs can indeed be manipulated and that mimicry affects both the target transcript stability and protein accumulation. Molecular and physiological characterization of the mimicry lines in comparison with wild-type plants provided strong support for a refined copper economy model. Importantly, our study also illustrates the potential of target mimicry as a means to manipulate miRNA-mediated regulation in bioengineering approaches.

Key words: Copper, micro-RNAs, protein, bioengineering

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141. Shamsul, Zakuan

Towards developing methods to increase uptake of palladium by plants for revegetation and remediation of mine wastes

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Waste materials (tailings) generated from mining processes contain significant amounts of palladium, which are considered uneconomical to be extracted using conventional methods. Studies have demonstrated that Arabidopsis thaliana (Arabidopsis) can accumulate palladium as nanoparticles in the plant tissues. In collaboration with the Green Chemistry Centre of Excellence at the University of York, we have recently demonstrated that this nanoparticle-rich material can be used as a high-value catalyst, without the need to extract the metals from the plant biomass [1]. One of the properties of palladium is that it occurs naturally in the zero valent form. This represents a problem for phytoextraction as transition metals are usually taken up by plants as cations. To overcome this problem phytoextraction of gold, which is chemically similar to palladium, uses cyanide-based methods to promote gold solubility in soil. The use of cyanogenic compounds is not a long-term, environmentally sustainable method for palladium phytoextraction. Alternative methods may come from a greater understanding of the biological processes involved. Our studies have identified genes that are strongly regulated by gold, including a discreet suite of divalent metal cations [2]. We are now extrapolating these investigations to palladium to investigate solubilisation, uptake and nanoparticle formation of palladium in plants.

Keywords: palladium, mine tailings, plant metal uptake, nanoparticles

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142. Shuvaeva, Olga

Phytoextraction of Trace Elements by Water Hyacinth in Contaminated Area of the Gold Mine Tailing

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The ability of water hyacinth (Eichhornia crassipes) to uptake major and trace elements (Hg, Ag, Ba, Cd, Mo and Pb from waters in gold mine tailing area was studied. All experiments were carried out in the field conditions without using of model approach. Bioconcentration (BCF) and translocation factors (TF) as well as elements accumulation by plant in different points of tailings dispersion halo were evaluated. It has been shown that water hyacinth demonstrates a high ability to accumulate the elements under investigation and may be characterized as hyperaccumulator, moreover, it is efficient in translocation as well. The general trend of the plant accumulation ability in relation to the studied elements corresponds to their content in the medium. As the distance from tailings increases, the concentration of Ag, Ba and Pb in plant decreases more clearly than that of Cd and Hg, while the amount of accumulated Mo doesn't drop significantly in accordance with its content in water. The high bioaccumulation ability of water hyacinth with respect to all studied elements in conditions close to extremal, which gives the hope for the possibility of its use for phytomining. However, it is rather a question of the nearest future.

Keywords: trace elements, phytoextraction, tailings

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143. Singh, Priyanka

Biomass characterization of locally available weeds as bioenergy feedstock: A case study

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According to the International Energy Agency bioenergy can serves as an exciting alternative and can provide 25 % of the world's energy needs by 2035. The exotic terrestrial weedy plants have been of particular interest because of their rapid growth, ability to tolerate poor growing conditions, and minimal input requirements compared with traditional bioenergy sources. However, there exist a knowledge gaps for selecting and cultivating these weeds as their biomass characterization is less investigated. In the present study four locally available terrestrial weeds (Parthenium hysterophorus, Lantana camara, Ageratum conyzoides and Bidnes pilosa) were characterized for their suitability as bioenergy feedstock. The weeds were collected from Doon university campus (30º 16º N, 78º 2º E), in Dehradun (Uttarakhand) India. The dry biomass was separated into plant leaves, plant stem and mixed biomass (leaves + stem). In Parthenium hysterophorus, average moisture content was 43.5-53.3 %, ash content was 2.8-3.3 %, volatile matter was 0.5-2.12 % and fixed carbon was 41.9-53.1%. The elemental composition reported 41.3-45.8 % C; 5.8-6.6 % H; and 2.7-3.8 % N. The biochemical characteristics predicted higher carbohydrate (39.8 %) and lipid (43 %) content in harvested leaves. The proximate analysis of Lantana camara offers moisture content of 14.0-37.3 %, ash content of 3.1-3.7 %, volatile matter of 0.54-2.13 % and fixed carbon of 57.7-81.4 %. The elemental composition (%) was C – 42.3-44.0; H – 5.5-6.1; N – 2.01-2.98. The carbohydrate and lipid were maximum in leaves i.e. 41 % and 40.8 %, respectively. The weed Ageratum conyzoides showcases average moisture content of 47.2-52.8 %, ash content of 2.53-3.94%, volatile matter 0.54-2.13 % and fixed carbon 57.7-81.4 %. The elemental composition was C 37.5-40.2 %; H 5.5-6.1 % and N 2.01-2.98 %. The leaves biomass offers higher carbohydrate and lipid content (69.5 % and 32.3 %). In Bidnes pilosa the moisture content was 29.7-56.1 %, ash content 2.96-3.58 %, volatile matter 0.8-2.12 % and fixed carbon of 38.7-66.4 %. The elemental composition was C 39.5-43.2 %; H 5.1-5.8 % and N 3.5 4.9 %. The carbohydrate and lipid was found to be maximum in stem i.e. 20.6 % and 36.4 %. The high heating value (HHV) was found to be maximum for Lantana leaves (25.4 MJ/Kg-15.8 MJ/Kg), followed by Lantana mix (21.8 MJ/Kg-14.1 MJ/Kg), Bidnes leaves (20.8 MJ/Kg-14.9 MJ/Kg) and Parthenium stem (19.3 MJ/Kg-13.2 MJ/Kg). The result suggested the adequacy of these terrestrial weeds as low cost, easily available feedstock for commercial use.

Key words: Weeds, volatile matter, carbohydrate, lipid, higher heating value

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144. Sirguey, Catherine

Phenanthrene-induced alterations to Noccaea caerulescens roots and consequences for Cd phytoextraction

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Remediation strategy of brownfields multi-contaminated by heavy metals and organic pollutants needs to address both kind of contaminants. A combined decontamination using simultaneous phytoextraction of metals and rhizodegradation of organic pollutants appears a promising solution. However, effect of organic pollutants on hyperaccumulators remains unknown especially regarding toxicity issues and phytoextraction efficiency. The aim of this work was thus to study the effect of phenanthrene (PHE), a representative polycyclic hydrocarbon (PAH), on the heavy-metal hyperaccumulator Noccaea caerulescens.

Seedlings of N. caerulescens were cultivated, during one (Exp1) or four weeks (Exp2) in a climatic chamber, on a nutritive agar medium non supplemented (control) or supplemented with 2 mM PHE and/or 5 µM Cd. From Exp2, we assessed plant growth, root architecture (WhinRhizo® software) and nutrition parameters (macro and microelements, ICP-OES). Root structural features (suberin lamellae and peri-endodermal layer) were observed using epifluorescence microscopy from Exp1.

PHE exposure significantly affected root and shoot biomass production with respectively 60% and 70% inhibition as well as root system length and surface. PHE promoted lateral root formation and inhibited root hair elongation and peri-endodermal layer development. Additionally, PHE reduced by 90% the net uptake of both macro and micro-elements (except for Na). Addition of Cd in the medium partly alleviated this inhibition in nutrient uptake but plants remained unable to take-up Cd. These results highlight the possible phytoextraction limitation for multicontaminated situations. Still complementary studies are needed to identify the critical PHE concentration inducing uptake alteration.

Keywords: Trace metals, organic pollutants, hyperaccumulator plants, physiology

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145. Skabelund, Lee R.

Monitoring hydrology and related factors to improve green roof planning, design, implementation, and management

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Recently green roof monitoring has increased dramatically – with landscape architecture faculty offering important contributions (e.g. Sutton et al 2012; Dvorak & Volder 2013). Researchers and designers recognize the need for monitoring that informs green roof design, implementation and management (Simmons et al 2008; Coffman & Waite 2010; Welker et al 2013). Multi-year green roof monitoring of hydrologic conditions in relation to substrates and plant types is vital if we are to improve how we design, implement, and manage these systems. Creating resilient, less-resource-demanding living roofs that fit with their larger eco-regional context and unique project conditions and objectives means understanding how green roofs function in regards to hydrologic, micro-meteorological, and other parameters. This presentation discusses ways to monitor green roof hydrology (precipitation, irrigation, runoff/outflow, evapotranspiration, and water storage), noting what has been learned from monitoring hydrology, temperatures, and vegetation on the Upper Seaton Hall Green Roof at Kansas State University. Understanding hydrologic and micro-meteorological conditions in relation to green roof substrate characteristics and plant growth/viability are essential to creating resilient extensive and semi-intensive green roofs. Monitoring green roof hydrology on integrated systems must address the following: 1) monitoring hydrologic inputs and outputs can be complicated by the fact that flumes and gauges may not capture low flows and are susceptible to debris blockages; 2) tipping buckets cannot capture precise precipitation rates that are very small or too large/rapid, and may only work for small areas since they can be overwhelmed by larger flows; 3) cisterns may overtop during large storms.

Keywords: semi-intensive green roofs, monitoring hydrology, vegetation and related factors, improving green roof design, implementation and management

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146. Soyoye, Adetokumbo M.

HEAVY METALS ACCUMULATION IN PLANTS IN INDUSTRIAL AREAS (EWEKORO AND SANGO OTTA) OF OGUN STATE, NIGERIA.

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Heavy metals accumulation in plants found around selected industrial areas of Ogun state, Ewekoro and Sango-Otta were assessed to determine their concentration. 28 plant and 8 soil samples were collected randomly from these industrialized areas. Samples were digested and cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb) and nickel (Ni) content determined by Atomic Absorption Spectrophotometeric method. The data collected was compared with the World Health Organization (WHO) guidelines for plant samples and National Environmental Standards and Regulations Enforcement Agency (NESREA) for soil samples. Also the Bioaccumulation factor (BAF) values were generated. Across sample points specific plants had metal concentration above the WHO guideline for a particular heavy metal. All the soil samples were below the NESREA recommended standard. Majority of the plants accumulated lead as indicated by their BAF values being greater than one. Cd is less bio-accumulated as it could not be detected by the AAS in most plants, therefore having BAF values <1. Cr, Cu, Ni were averagely accumulated amongst plants. However, the following plants could be suggested as hyperaccumulators C. dactylon, Solenostermon monstahys, Securinega virosa, Triumphetta rhomboidea, Elytrigia repens, S. nigrum, T.procumbers and Chromolena odorata; because of the high BAF values. These plants could serve as bioindicators for heavy metal pollution and as agents for phytoremediation of polluted soils. To this end, it is therefore recommended that further research with the use of molecular, genetic and cytological tools need to be implemented to ascertain the level of heavy metal pollution and adoption of best phytoremediation strategy.

Keywords: phytoremediation; heavy metals; industrial Pollution; hyperaccumulators.

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147. Struckhoff, Garrett

Phytoremediation of 1,4-Dioxane
with Sweet Basil and Common Radish

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1,4-dioxane is a hazardous volatile carcinogen that contaminates soil and groundwater. Unlike many other organic contaminants, dioxane demonstrates low interaction with soil organic matter and travels rapidly with groundwater flow. A design intended to treat a TCE or TCA plume could easily be insufficient for dioxane contamination. Phytoremediation has been shown to be an effective method of ameliorating groundwater contaminated with chlorinated organic solvents but studies have not conclusively shown its potential with dioxane. The purpose of this experiment was to observe the phytoremediation of the harmful organic co-contaminant, 1,4-dioxane, through uptake by Ocimum basilicum (sweet basil) and Raphanus sativus (common radish).

The first phase of this project involved growing basil and radish plants in reactors contaminated with a control (0%), low (0.015%), medium (0.15%), and high (1.5%) concentrations of dioxane. A no-plant control at medium concentration was also monitored to measure the general volatility of dioxane in the system. After 29 days of growth for basil and 26 days for radish, the plants, roots, and soil were harvested separately and sealed into glass vials. Using gas chromatography, measurements of dioxane headspace concentrations were taken from the sealed vials.
The results indicate that dioxane removal rate is inversely proportional to dioxane concentration. In 29 days, sweet basil plants were able to remove 48.3% of soil dioxane at the highest concentration and 91.8% at the lowest concentration. Radish showed similar results in 26 days with 70% dioxane removal at the highest concentration and 99% removal at the lowest concentration. The data also indicate that higher concentrations resulted in plant growth inhibition; as measured by biomass production and water uptake. With the highest concentration of dioxane, sweet basil and radish showed 77% and 81% biomass growth inhibition, respectively.

Keywords: dioxane, radish, basil, garden vegetables, phytovolatilization

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148. Szymaszek, Kathryn

Enhanced Treatment Wetlands Using Native Species for Ethanol Removal

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Roux Associates designed and is planning for the installation of an enhanced subsurface flow constructed treatment wetland for the treatment of petroleum contact water at a bulk petroleum terminal in Albany, New York. The contact water is composed of gasoline/water and distillate/water mixtures generated and received during routine maintenance activities at petroleum facilities. Consistent with typical petroleum-impacted waste streams, constituents of concern in the wastewater include benzene, ethylbenzene, toluene and xylenes (collectively referred to as BTEX), and high concentrations of ethanol. The existing WWT system was an aging system that required high O&M activities with costly chemical additions and was unable to adequately treat the elevated concentrations of ethanol now present in fuels.
The contact water is first pre-treated through a tray air stripper and catalytic oxidizer for BTEX removal. The ethanol laden water is then conveyed through 2 parallel subsurface flow wetlands populated using native species where the ethanol is removed via aerobic biodegradation. Treatment efficiency is further improved through incorporation of supplemental subsurface aeration methods to support the microbial populations during winter operations and ensure the aerobic conditions are readily available for microbial degradation. Treated effluent is then conveyed to the nearby river for discharge under the SPDES program.

Keywords: BTEX, ethanol, subsurface flow, aeration, native species

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149. Thijs, Sofie

A molecular-ecological approach for trinitrotoluene contaminant-detoxification in the rhizosphere of Acer pseudoplatanus

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The goal of rhizoremediation is to use plants to degrade or otherwise detoxify organic contaminants. Plants mainly influence this process indirectly through the stimulation of rhizosphere microorganisms. Therefore, getting a detailed understanding of the effect plants and contaminants have on the composition and activities of rhizosphere bacteria could help to optimize rhizoremediation. We used pyrosequencing, activity profiling and single isolate genome sequencing to characterize bacterial communities inhabiting bulk and rhizosphere soil surrounding Acer pseudoplatanus trees in two chronically trinitrotoluene (TNT)-contaminated soils. Phylogenetic analysis revealed that TNT decreased community diversity and shifted community composition in bulk soils irrespective of soil matrix. Community composition in the contaminated rhizospheres was significantly different from non-contaminated soils. This was reflected by a reduced diversity and species richness in the contaminated soils. Abundance of Alpha- and Gamma-proteobacteria was directly related to high TNT-concentrations in the bulk soils. Proteobacteria were dominant in all rhizosphere soils while Acidobacteria were enriched in contaminated rhizospheres. The presence of genes involved in xenobiotic degradation was higher in contaminated soil as indicated by predictive metagenome reconstruction. Reassuringly, enzymatic tests and a detailed genomic analysis revealed the presence of TNT-denitrating enzyme activities of the Old-Yellow-Enzyme family in the genera Pseudomonas and Raoultella. Together, our study highlights that combining examination of microbial community distribution patterns, single genome analyses, soil properties and plant effects has great potential for helping to understand in situ rhizoremediation.

Keywords: soil, trinitrotoluene, 16S rRNA gene pyrosequencing, Old Yellow Enzyme, rhizoremediation

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150. Thomas, Frank

A Decade of Phytoremediation Projections by Eucalyptus Trees Preventing Contaminated Plume Migration

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At a former tin smelter site in Texas City, Texas, phytoremediation started in 2002. Primary contaminants at the Site are heavy metals (barium, cadmium, chromium, copper, lead, and magnesium). In 2013, the same stand of trees was evaluated using identical methods, allowing a comparison of the ability of the matured eucalyptus trees to hydraulically control the migration of the impacted groundwater, and the making of more refined projections on actual transpiration measured by sap flow sensors. This data comparison presents a unique opportunity to generate a eucalyptus crop specific Kc (crop coefficient), which in turn provides a well-accepted factor to apply to weather-derived evapotranspiration potential index (ETo) based transpiration algorithms. The transpiration compared to rainfall provides hydraulic models with a water balance approach to contaminated plume remediation and migration prevention. In the 2002 evaluation of three-year-old Eucalyptus camaldulensis, the analysis of transpiration and water consumption projection was based on measurements by Dynamax TDP sap flow sensors, the leaf area index, the weather-based ETo and rainfall. We present the latest Kc factors for 2013 and the results of ETo projections, and the expected water deficit created by the mature stand at the projected density. The presentation summarizes the differences in transpiration rates, the Kc changes, and the expected annual drawdown in dry and wet years. With the refined sap flow and Kc factors for modelling, we improve the long term projections of plume migration prevention, and enable a refined projection of plume remediation by transpiration and plant – root activity.

Keywords: transpiration, sap flow, water balance

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151. Thomas, John C.

The Biodegradation of Polystyrene by Soil Bacteria

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Plastics are a significant source of pollution and a hazard to many organisms including humans. To isolate candidate polystyrene degraders, we screened bacterial isolates from a nearby steel plant, by growing them without a carbon sourced in 96 well polystyrene plates for 5-6 weeks in vitro vs. controls. Next active metabolism was determined using a dehydrogenase assay (WST-1). Several positive isolates were further characterized and rDNA sequencing conducted. The top performer (2C73) was Arthrobacter aurescens FRSP (Genbank KF110992). Unlike previously described polystyrene degraders with two component mono/dioxygenase systems, 2C73 differed. Generally styrene monooxygenase (SMO) promotes styrene to polyhydroxyalkanoate conversion and accumulation in Pseudomonas putida and Rhodococcus rhodochrous. We found that 2C73 does not contain significant SMO activity nor activity promoting the degradation several small polyaromatic hydrocarbons. However, when styrene was used as a carbon source, 2C73 growth was quite robust, suggesting the styrene degradation pathway may be unique in this isolate. When co-incubated in carbon free medium plus polystyrene peanuts, 2C73 demonstrated a 25% reduction in polystyrene mass after 14 months of cultivation. Several plasmids were also detected in this isolate. In the future we wish to examine the metabolites of the styrene degradation observed using an HPLC, already in hand. The penultimate goal of this work is to recover the gene(s) in this potentially novel polystyrene remediation pathway and facilitate this activity in remediation strategies using microbes and higher plants.

Keywords: Plastic bioremediation, phytoremediation, plant associated microorganisms

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152. Thomas, Manjula

Phytoextraction potential of a weed (Solanum nigrum) Grown in lead contaminated soil.

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This study was aimed to determine the uptake and accumulation potential of a weed (Solanum nigrum L.) for phytoremediation of soil contaminated with lead. Plants were grown in soil spiked with 0, 25, 50, 100, 200, 250 mg/kg Pb, individually. Plants sample (root and shoot) were analyzed for Pb content at 25, 50, and 75 days and accumulation trends were characterized. A steady increase in Pb accumulation with increasing metal concentration and exposure period was observed for all treatments. Accumulation of Pb in roots was found to be higher than that of shoots. Statistically significant difference ($P \leq 0.001$) in mean metal content in root and shoot at successive days of study was recorded. Effect of Pb on growth and physiology was also evaluated. At higher Pb levels, root and shoot length, and biomass of test plant were reduced significantly. Although, growth was delayed initially, it was comparable to control at the end of the study. Chlorophyll and proline content declined with the increase in Pb concentration at 25 and 50 days after treatment. However, at 75 days values were more or less comparable to the control values showing the adaptability of test plant in Pb contamination. Considering the accumulation ability, BCF > 1 (Bioconcentration factor) and TF < 1 (Translocation factor) established S. nigrum as a potential candidate plant for phytoremediation. Hence, phytoremediation employing indigenous weed species like S. nigrum can be an ecologically viable option for sustainable and cost-effective management of heavy metal contaminated soils.

Keywords: Solanum nigrum, Lead, Phytoremediation, Phytostabilizer

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153. Thomas, Paul

Phytotechnology Cost Benefits: Twenty Eight Years of Project Experience

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Paul Thomas and Edward Gatliff have been applying phytotechnologies to hazardous waste remediation for twenty eight years. Presented here are cost data associated with projects for which direct comparison is possible between successful phytoremediation and more traditional remediation methods. The primary focus is on organic chemical contaminants in soil and groundwater. Phytoremediation of agricultural chemicals in soil is compared to traditional excavation and disposal. Pump-and-treat technology for the remediation of volatile organic compounds in fractured bedrock is compared to the application of TreeWell® technology (a plant-based, hybridized pump-and-treat technology). Case descriptions include cost comparisons of hybridized phytotechnologies to in-situ chemical treatment; passive barriers; excavation and disposal; pump-and-treat; and other traditional remediation methods.

Keywords: Phytoremediation, phytotechnologies, phytotechnology, hazardous waste remediation, agricultural chemical, soil, groundwater, TreeWell, pump-and-treat, hybridized pump-and-treat, passive barriers, in-situ chemical treatment

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154. Tiwari, Sarita

Identification of arsenic resistant endophytic bacteria from roots of Pteris vittata Indian ecotype and assessment of their potential for remediation

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Mitigation of arsenic (As) pollution is a topical environmental issue of high R&D priority. Endophytic bacteria were isolated from the roots of the As hyperaccumulator Indian ecotype P. vittata and characterized its plant growth promoting and As transformation characteristics. A total of 8 endophytic bacteria marked as E1-E8 were isolated from P. vittata roots grown in 25 mg As kg-1 soil for sixty days, and studied for Minimum Inhibitory Concentration, As transformation test and PGP characteristics i.e. Siderophore, Indole Acetic Acid (IAA) production, Phosphatase and ACC deaminase activity. Arsenic transformation ability of isolates was detected using arsenite oxidase (aox) and arsenite transporter (arsB) gene specific primer. On the basis of 16S rDNA sequence analysis, the identified isolates belonged to proteobacteria, firmicutes and bacteroidetes particularly in genera Bacillus, Enterobacter, Stenotrophomonas and Rhizobium. All the isolates were As tolerant, but E4 showed highest tolerance up to 1000 mg L-1 concentration. Five isolates showed IAA positive, strain E4 had highest IAA production about 60ug/ml, and two isolates exhibited siderophore activity. Phosphatase activity was present in only isolate. E4 while ACC deaminase activity was absent in all the isolates. E2 and E5 showed dual characteristics of arsenite (AsIII) oxidation and arsenate (AsV) reduction by silver nitrate test. aox gene was observed only in strain E1 & E2, while arsB gene was amplified in all isolates except E6 and E8. Our study shows scope of utilizing these endophytes for up gradation of phytoextraction process using the Indian ecotype P. vittata similar to other species.

Keywords: endophytes, phytoremediation, Plant Growth Promoting Bacteria (PGPB), Minimum Inhibitory Concentration (MIC), Indole Acetic Acid (IAA)

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155. Tong, Yan' an

EFFECTS OF ORGANIC FERTILIZERS ON THE HEAVY METAL ABSORPTION OF BETA VULGARIS L.VAR.CICLA IN SOIL CONTAMINATED WITH CADMIUM

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A study about the effects of organic fertilizers on inhibiting heavy metal absorption of Beta vulgaris L.var.cicla (i.e. an agricultural plant capable of absorbing high amount of Cd) in soil contaminated with Cd was conducted through outdoor pot-culture and small-scale field experiments. The results showed that fertilizing 1.8kg cow manure + 0.09kg lime was considered to have the best impact on growth, development and potentially inhibit the Cd absorption of B. vulgaris in particular and agricultural crops in general. Additionally, the lower the pH, the higher the mobility of Cd metal ions was, which strengthened the Cd absorption of B. vulgaris stems. Under pH more than or equal to 7.89, heavy metals tended to link organic compounds to form complexes, which reduced the flexibility and prevented the Cd accumulation in plants. Due to the development of plants organic matter was not washed out. At the same time, the amount of remaining parts such as organic fertilizers, roots, stems and leaves of increased the content of organic matter (OM%), total phosphorus (P%), total potassium (K%) and total nitrogen (N%) in soil.

Key words: Beta vulgaris L.var.cicla, organic fertilizers, Cd, phytoremediation.

156. Torre-Roche, Roberto De la

Trophic transfer of engineered nanoparticles in terrestrial food chains

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The trophic transfer of engineered nanoparticles from soil through terrestrial food chains is being measured. Bulk or nanoparticle (NP) cerium oxide or lanthanum oxide were added to soil (0-1000 mg/kg) with zucchini or lettuce. After 28 days, the plant Ce and La content was determined and leaves were fed to crickets or darkling beetles for 14 days. The herbivores were fed to wolf spiders or mantids for 7 days. The Ce and La content of arthropods and feces was measured. NP Ce exposure had little effect on total biomass, although zucchini flower production was suppressed. Zucchini Ce content was greater with the NP exposure. The flowers, leaves, stems, and roots of bulk exposed plants contained 93.3, 707, 331, and 119,000 ng/g, respectively; nanoceria-exposed plants contained 153, 1510, 479 and 567,000 ng/g, respectively. Crickets fed bulk and NP-exposed leaves contained 15 and 34 ng/g, respectively. Spiders consuming bulk-exposed crickets had non-detectable Ce but NP-fed spiders contained Ce at 4.9 ng/g. Upon lanthanum exposure, plant mass was reduced across all treatments but there was no difference in lettuce La content based on particle size. Although NP-exposed crickets contained less La than the bulk, mantid La content did not differ with particle size. These findings show that some nanoparticles bioaccumulate greater levels than bulk materials and that this can result in trophic transfer and food chain contamination. Current work is focusing on the impact of particle weathering in soil on trophic transfer, as well as how vertebrate carnivores (lizards) respond to nanoparticle-containing food.

Keywords- Nanotoxicology, Trophic Transfer, Engineered Nanomaterials

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157. Treesubsuntorn, Chairat

Application of Botanical Biofilter for Gaseous Trimethylamine Removal by Sansivieria kirkii: Effect of Plants and Microorganisms

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Trimethylamine (TMA) is a compound which present in food industry and can contaminate both water and air. TMA contamination can case strong smell. High concentration of TMA can cause pathological changes in many human organs. High TMA accumulation has been found in many food industries. Phytoremediation is considered to be an effective method for gaseous TMA remediation; according to the results from our screening of 32 plant species for TMA removal, Sansivieria kirkii can completely remove 100 ppm of TMA within only 24 hours. This plant species with 260 cm2 leaf area, grown in 500 g soil, was used to remove TMA in a botanical biofilter system with various flowrate of 0.03-0.3 l/min where 100-1000 ppm TMA were applied as initial TMA concentration. Under 100-300 ppm TMA condition with 0.1 l/min flowrate, the system could remove 100% of TMA in the first 7 days; stable TMA removal efficiency of around 85% was found after day 7. Also, the system without a plant (control conditions) could also remove around 82-95% of TMA in 15 days. Loading rate and elimination capacity were analyzed and the system showed that the loading rate could be increased, to be higher than 700 mg/m3/h in both treatment and control conditions. Therefore, the effect of microorganisms in the system was investigated. Epiphytic bacteria (EP), endophytic bacteria (ED), and rhizosphere bacteria (RH) were isolated. Pure cultures of microorganisms were used to remove gaseous TMA in a closed system. Many microorganisms such as EP1, EP4, ED1, ED2, ED3, RH2 could remove TMA rapidly. High TMA removal microorganisms were also identified by 16S rDNA.

Keywords: Botanical biofilter, Endophytic bacteria, Food industries, Sansivieria kirkii, Trimethylamine

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The authors would like to thank the Higher Education Research Promotion and National Research University Project of Thailand, Office of the Higher Education Commission.

158. Tsao, David

An Industrialist's Perspective on Gaining Regulatory and Stakeholder Acceptance of the Suite of Phytotechnologies

David Tsao*, Ph.D., BP and the Interstate Technology and Regulatory Council

Like all remediation technologies, the use of phytotechnologies to address site environmental liabilities requires regulatory and stakeholder acceptance. However, phytotechnologies are just that…a suite of technologies where each individual technology requires substantial demonstration and validation in order to be accepted. When applied to organic contaminants such as petroleum hydrocarbons, chlorinated solvents, and even some persistent pollutants, the general acceptability has gained significant traction over the past decade or two. Although the use of phytotechnologies for inorganic constituents such as heavy metals, radionuclides, and salts has been developing for several more decades in comparison, the acceptance is lagging behind as an accepted cleanup at real world sites. Of course, the fundamental difference between organic and inorganic constituents lies in the degradability resulting in in situ cleanup (preferred contaminant degradation and reduction) versus containment or active removal (phytoextraction). When simply looking at phytotechnologies to manage hydraulics (capturing relatively unimpacted groundwater, surface water, or stormwater), the acceptance is again fairly high, simply due to the accepted truth that all plants require water and are natural filters to non-point source pollution. One avenue that has been quite successful in gaining regulatory and stakeholder approval of many remediation technologies is through the Interstate Technology and Regulatory Council (ITRC). Formed 20 years ago, this organization is a collaboration of State and Federal regulatory agencies, industry partners, academia, and public and tribal stakeholders whose mission is essentially to develop technical and regulatory guidance and training "by regulators, for regulators". ITRC has published several documents facilitating regulatory and stakeholder acceptance of nearly the entire gamut of phytotechnologies including hydraulic barriers, landfill covers, constructed wetlands, mitigation wetlands, organic phytoremediation, and metal/radionuclide sequestration. Most recently, ITRC has even formed a team to develop guidance and recommendations for stormwater best management practices, focused on performance verification.

Keywords: regulatory acceptance, stormwater, phytotechnologies

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159. Tu, Chen

Biodegradation Dynamics of Polychlorinated Biphenyls in the Rhizosphere of Alfalfa-Rhizobium Symbiosis

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Polychlorinated biphenyls(PCBs) are typical chlorinated aromatic compounds that are characterized by high physical and chemical stability in the environment and categorized as persistent organic pollutants (POPs). Pot experiment with a three –compartment-rhizobox was conducted to explore the dissipation of PCB 77 and the microbial ecological restoration effects in the rhizosphere of alfalfa-rhizobium symbiosis during phytoremediation.

With the increasing of culture time, the concentration of PCB 77 in the rhizospheric soil decreased significantly. The dissipation gradient in different soil zones followed the order: rhizosphere > near rhizosphere > far from rhizosphere. After 105 days, reduction rates of PCB 77 in soil zones of rhizosphere, near rhizosphere and far from rhizosphere are 90.9%, 80.5% and 31.7% respectively. Real-time fluorescence quantitative PCR, Biolog-ECO microplate and DGGE were employed to study the microbial community structure and diversity. Results showed that diversity of microbial community was positively correlated to the reduction rates of PCB 77 in the soil. Cultivation of alfalfa-rhizobium symbiosis could significantly enhance the dissipation of PCB 77 in the rhizosphere by stimulating the bacterial quantity, improving the microbial activity and increasing the diversity of microbial community in the rhizosphere. Microbial degradation of PCB 77 stimulated by alfalfa-rhizobium symbiosis is the principal mechanism of PCB dissipation in the rhizosphere.

Results of this study would be useful for better understanding the mechanism and application of microbial enhanced phytoremediation of PCB contaminated soils.

Keywords: alfalfa-rhizobium symbiosis, biodegradation, microbial community structure and diversity, PCB dissipation, rhizosphere

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161. Vanek, Tomas

The nanoparticle effect on plant metabolisms of Arabidopsis thaliana

Radomira Vankova, Premysl Landa, Petre Dobrev, Sona Prerostova, Vojtech Knirsch, Tomas Vanek*, all IEB ASCR

Nanoparticles represent more and more developing area today, with versatile use. However, very little is known about their effects on living organisms, including plants. As plant interactions with the environment are mediated by plant hormones, we decided to evaluate the effect of different concentration (0.8 to 100mg/l) of ZnO nanoparticles on hormonal pools in Arabidopsis thaliana plants. The tested nanoparticles were in the size of 30 nm. Taking into account that characteristic feature of plant hormones is their intensive cross-talk in the regulation of specific processes, plant responses were followed at the level of six type of phytohormones in apices, leaves and roots. All nanoparticle concentration suppressed the biosynthesis of the growth promoting hormones cytokinins and auxins in apices. In contrast, the active cytokinins were elevated by nanoparticle concentration (20 and 100 mg/l) in the roots. Similar response was observed in case of active gibberellin GA1. Higher concentration resulted in up-regulation of the stress hormone abscisic acid in apices and leaves. In case of salicylic acid, stimulation was found in leaves and roots. The other stress hormone jasmonic acid (as well as its active metabolite jasmonate isoleucine) were suppressed at the presence of nanoparticles. The achieved results indicate that different nanoparticle concentrations specifically affect plant hormone pools and thus the physiological state of plants as well as generally the ability of plants to remove the nanoparticles from liquid media and/or waste waters.

Keywords: nanoparticles, Arabidopsis, plant hormones, plant metabolisms, waste waters

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Acknowledgement:
This work was supported by LD14125 and LH11047 MYES grants.

162. Vanek, Thomas

Phytoremediation of veterinary and human pharmaceuticals. From laboratory to real scale

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In the recent time, the global production of the human and veterinary pharmaceuticals strongly increases together with their affordability not only in developed countries, but due their availability and decreasing prices also in Third World countries. Nevertheless, among the most polluted areas belong developed and industrial countries with high standard of living and population density.
The one of the most significant problems is persistence of the pharmaceutical residues and their metabolites in the environment. Many of them do not exhibit acute toxicity for water ecosystems, but have a cumulative effect for nontarget organisms.
In this contribution we will present our results with veterinary and human drug praziquantel, which is widely used to treat schistosoma and liver fluke and widely used human drug ibuprofene.
The laboratory experiments with in vitro and in vivo cultures Phragmites australis proved presence of the several metabolites of oxidation in cultivation medium contained both pharmaceuticals. Achieved result suggests the ability of the plant cells to accumulate and transform veterinary pharmaceuticals to the products of the first and second detoxification step.
This results were finally tested in real scale in constructed wetland with combined vertical and horizontal flow designed for agriculture waste waters cleaning. Elimination of phosphorus, nitrogen and ammonia in this arrangement will be discussed too.

Keywords: phytoremediation, pharmaceuticals, waste waters, constructed wetland

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Acknowledgement:
This work was supported by Grant Agency of the Czech Republic project No. 14-22593S, TA01020573 project of the Technology Agency of the Czech Republic and MHMP CZ.2.16/3.1.00/21519

The nanoparticle effect on plant metabolisms of Arabidopsis thaliana

Radomira Vankova, Premysl Landa, Petre Dobrev, Sona Prerostova, Vojtech Knirsch, Tomas Vanek*, all IEB ASCR

Nanoparticles represent more and more developing area today, with versatile use. However, very little is known about their effects on living organisms, including plants. As plant interactions with the environment are mediated by plant hormones, we decided to evaluate the effect of different concentration (0.8 to 100mg/l) of ZnO nanoparticles on hormonal pools in Arabidopsis thaliana plants. The tested nanoparticles were in the size of 30 nm. Taking into account that characteristic feature of plant hormones is their intensive cross-talk in the regulation of specific processes, plant responses were followed at the level of six type of phytohormones in apices, leaves and roots. All nanoparticle concentration suppressed the biosynthesis of the growth promoting hormones cytokinins and auxins in apices. In contrast, the active cytokinins were elevated by nanoparticle concentration (20 and 100 mg/l) in the roots. Similar response was observed in case of active gibberellin GA1. Higher concentration resulted in up-regulation of the stress hormone abscisic acid in apices and leaves. In case of salicylic acid, stimulation was found in leaves and roots. The other stress hormone jasmonic acid (as well as its active metabolite jasmonate isoleucine) were suppressed at the presence of nanoparticles. The achieved results indicate that different nanoparticle concentrations specifically affect plant hormone pools and thus the physiological state of plants as well as generally the ability of plants to remove the nanoparticles from liquid media and/or waste waters.

Keywords: nanoparticles, Arabidopsis, plant hormones, plant metabolisms, waste waters

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Acknowledgement:
This work was supported by LD14125 and LH11047 MYES grants.

163. Varaprasad, Majeti Narasimha

Biomass from Bioremediation as Feed Stock for Boosting Bioeconomy

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Globally, today the growing economy, extensive industrialization and utilization of bioresources have resulted in environmental contamination and pollution. Large amount of biological wastes is generated in developing and developed nations. The challenge is to develop profitable solutions to utilize this biological waste for production of value chain and value additions appears. In these presentation strategies to utilize biological waste for co-generation of value chain and value addition products are covered.

The growing need for biomass for conversion to biofuels requires lignocellulosic-rich raw materials. Phytoremediated phytomass is one such option to produce fuel like methanol, biodiesel, synthetic gas and hydrogen (using thermal and thermo chemical processes by direct or indirect liquefaction or gasification) and ethanol (through hydrolysis and subsequent fermentation). Biorefinery processes (the sustainable processing of biomass to a spectrum of marketable products and energy) is an absolute necessity and it is the key to meet this vision towards bio-based economy.

Brassica juncea (Indian mustard) Helianthus annus (sunflower), Prosopis juliflora, bamboo, and Pistia stratiotes (water lettuce), are potential environmental crops grown for different purposes including energy generation. Annuals and perennials, including algae in wastewater ponds generate huge amount of waste. Management and production of phytoremediation crops in contaminated substrates serves as a sink for contaminants with possibility for co-generation of econonomic products. Co-generation of beneficial products foster circular economy through biorefinery approach.

Key words: biodiesel, bioeconomy, biomass conversion, biorefinery, carbon sequestration, circular economy, constructed wetlands, energy crops, environmental cleanup, industrial crops, ornamental crops, value additions, value chain products

164. Verma, Rashmi

Utility of duckweed system in wastewater treatment and bio-energy feedstock production

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The ideal biomass destined to be used for bioenergy production should have efficient solar energy conversion resulting in high yields, needs low agrochemical inputs, has a low water requirement and has low moisture levels at the time of harvest. Conventionally used plant species may not address the issue of sustainability as their utilization demarks the direct interference with food security. Duckweed deemed to be potential candidate for bioenergy generation due to its variability to grown in different environmental and climatic conditions. L.gibba offers massive wastewater remediation potential as these inculcate wastewater nutrients to biomass generation. The duckweed based wastewater treatment system may fulfil a dual objective of water reclamation and energy rich biomass generation. In the present study, nitrate (NO3−N), phosphate (PO43-), sulphate (SO42-), chemical oxygen demand (COD) and biochemical oxygen demand (BOD5) offers average removal of 73.8, 70.3, 84.3, 71.7 and 74.9%. The RGR (g/m2 d) of 13.6, resulted in essential metabolite production yield of 7.7 g/m2 d for total sugar, 4.9 g/m2 d for starch, 7.6 g/m2 d for protein and 1.9 g/m2 d for lipid. The bioenergy potential of harvested biomass evaluated in terms of HHV (ranged between 15.07 – 18.58 MJ/Kg) showcases huge possibility. The fatty acid composition validates high percentage of C16:0 (Palmitic acid) 37.68%, C18:2 (Linoleic acid) 18.11%, C18:3 (Linolenic acid) 33.76% in extracted lipid. The use of L.gibba as bioenergy feedstock is therefore, consider as a remarkable alternative as it offers decentralized plant production, utilisation of wastewater, higher energy return on investment, potentially greater economically efficiency, equitable resource distribution, little or no conflict with food resources, and much lower greenhouse gas emissions and other environmental effects.

Key words: Nutrient removal; Starch; Lipid; Palmitic acid; Linoleic acid; High Heating Value

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165. Via, Stephen M.

Physiological and morphological responses to explosives contamination across plant functional groups

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Explosive compounds induce negative effects on vegetation but little is known of how different functional types respond to contaminant mixtures. This is particularly important as explosive mixtures are responsible for the contamination of large portions of the globe. The objective of this experiment was to compare physiological and morphological responses to explosive contamination of different plant functional types, spanning several genera. Representatives of Vitus (woody vine), Cyperus (herbaceous sedge), and Ulmus (woody tree) genera were monitored for 8 weeks in soil amended with 500 ppm Composition B (60:40 RDX:TNT; n=5). Photosynthesis, chlorophyll fluorescence, stomatal conductance, plant height, leaf count, and necrosis of the leaves were recorded biweekly. At the end of the experiment biomass and uptake (via HPLC) were quantified. Significant leaf drop, chlorosis, necrosis, area reduction, and curling were evident in woody genera, while Cyperus showed no morphological responses. All plants expressed some form of physiological impact at the end of the experiment. Ulmus and Cyperus had significant reductions in root biomass, and Vitus exhibited significant reductions in leaf biomass. Uptake analysis showed that leaf and root contaminant concentration varied across functional groups. All three genera were capable of tolerating Compostion B, suggesting that these genera are capable of growing and potentially thriving on contamination soil. It also shows the potential for using native or naturalized species in continued research on environmental impacts on explosives.

Keywords: Composition B, Functional Types, Morphology, Physiology, Native Species

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166. Wan, Xiaoming

Study on the arsenic mobilization and absorption mechanisms in an intercropping system of Pteris vittata and mulberry tree

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The health risks posed by soil arsenic (As) contamination have received increasing attention. Phytoextraction using As hyperaccumulator Pteris vittata L. has been given specific focus. Intercropping of P. vittata and economical crops is now being widely promoted in slightly or moderately As contaminated farmlands. However, the process of As mobilization and absorption in the intercropping system is not clear yet. This study conducts pot experiments to study the As uptake by the intercropping system of P. vittata and mulberry tree. Based on the assumption that hyperaccumulator P. vittata can mobilize As in rhizophere and that P. vittata and mulberry tree have different tendencies to approach As,Synchrotron Radiation X-ray Absorption Spectrum and X-ray Phase Contrast Imaging are utilized to disclosed the As species and root architecture in the rhizophere. The impacts of intercropping system on the transfer and transportation process of As from soil to plant in the rhizophere of the intercropping system are to be elucidated. Results will be instructive for the optimization of phytoremediation technology using intercropping system.

Keywords: Arsenic, intercropping, mulberry tree, Pteris vittata,

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167. Wang, Huixia

Suitable tree species and spatial structure of green land for alleviating the particulate matter pollution in the urban area of Beijing

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Urban green land plays an important role in controlling particulate matter (PM) pollution, thus improving urban air quality. However, choice the suitable plant species and structure is the basis for controlling PM pollution using plants. In this paper, we measured the captured amount of PM and its fraction (PM2.5, PM>2.5) per unit leaf area for common plants in 16 sampling plots which with different plant structures. The total PM retention amount of the sampling plots and the PM retention of per unit green land area were calculated as well. Sampling plots with main plants as trees like Pinus tabulaeformis, Paulownia Sieb, and Sabina chinensis have higher PM and PM2.5 retention amounts than those with shrubs like Euonymus japonicus, Ligustrum quihoui, and Hibiscus syriacus. The PM and PM2.5 retention ability is related to not only dust retention amount per unit leaf area but also total leaf area. Urban green land has limited area, so shrubs with smaller canopy can been chosen to plant with higher trees with larger canopy for increasing green quantity on unit green area. In addition, evergreen plants also need to been chosen to ensure enough dust retention amount of green area from late autumn to early spring.

Keywords: plant choice, plant structure, particulate matter retention amount, size fraction

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168. Wang, Jiameng

Investigation of Selenium Hyperaccumulation Mechanisms in Stanleya pinnata: RNA Sequencing Pinpoints Potential Genes for Phytoremediation and Biofortification

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The element selenium (Se) is both a nutrient and a toxin, depending on the concentration. Selenium is similar to sulfur, and readily taken up and assimilated by plants. Plants containing Se may be used to alleviate both Se deficiency and toxicity in humans and livestock, through the phytotechnologies of biofortification and phytoremediation, respectively. Of particular interest are so-called hyperaccumulator species, which can concentrate Se up to 1.5% of their dry weight in the form of anticarcinogenic aminoacid forms (methyl-selenocysteine, in particular). These plants not only accumulate and tolerate extreme Se levels, but also preferentially take up selenate over sulfate, which is attractive when plant Se extraction is needed in high-sulfur environments. Selenium hyperaccumulator species may be used directly, and may also offer a valuable resource for genes to transfer to crop species. To pinpoint genes involved in Se accumulation and tolerance, a transcriptome study was performed comparing hyperaccumulator Stanleya pinnata (hyperaccumulator) with Stanleya elata (nonaccumulator) using RNA sequencing (Illumina platform, +/- selenate, root and shoot, n = 3). Interesting genes for further study that were expressed at much higher levels in the hyperaccumulator include a gene encoding a potential selenate transporter, genes involved in selenate assimilation (particularly an ATP sulfurylase), an aminoacid transporter gene and a gene encoding a receptor that may trigger these Se responses. These will be further characterized via expression in yeast and Arabidopsis.

Keywords: selenium, hyperaccumulation, mechanisms, phytoremediation, biofortification

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169. Weeks, Joseph

An Assessment of the Trace Element Exposure Risk to Urban Brownfields Gardeners via Inhalation.

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Urban gardening has been experiencing increasing popularity around the United States causing the scientific community to respond with research to determine optimal growing techniques and explore associated human health risks. Unfortunately, many urban soils are found to be contaminated with organic compounds and/or trace elements, so proper consideration must be taken to protect growers from these seemingly "invisible" issues. Three pathways of exposure are typically cited for soil-borne contaminants to enter the human body: ingestion of soil directly, consumption of produce containing contaminants or superficially contaminated with soil, and inhalation of soil dust. The first two modes have received much attention, however the contribution of the inhalation route to raising the human body toxin burden has not been adequately studied. In an effort to begin ameliorating this deficiency, a personal sampling train was utilized to quantify the amount of soil one could reasonably expect to respire while rototilling a garden. Dust samples were captured on porous PTFE disc filters in which air was pulled through by a small pump as the activity took place. Total inhalable dust was determined gravimetrically, and high-resolution scanning electron microscope- energy dispersive X-ray spectroscopic (SEM-EDS) analysis was used to characterize the dust particles. Data collected at the Washington Wheatley Community Garden (Kansas City, MO) suggests that the inhalation exposure pathway is only a minor avenue for soil-bound contaminants to enter the body, but further investigation is required. Soil water content appears to exhibit the greatest influence on the amount of dust generated by soil tillage.

Keywords: lead, brownfields, gardening, inhalation, exposure risk

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170. Weyens, Nele

Promiscuous dispersal of biodegradation genes: a key to improve endophyte-enhanced phytoremediation?

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The concept of endophyte-enhanced phytoremediation of organic contaminants implies the use of degrading, plant growth-promoting endophytes to reduce phytotoxicity and evapotranspiration. In order to achieve a stable endophyte-enhanced phytoremediation, it is essential that the degradation genes (located on a plasmid) from the inoculated endophyte are transferred to members of the indigenous population. The host-range of the plasmid strongly determines the success of such a horizontal gene transfer while the frequency of the transfer is regulated by its dispersal capacity. Therefore, we designed a broad host-range plasmid for cloning and promiscuous dispersal of biodegradative genes.

Two plasmids (221 and 251) with a broad host-range origin of replication from the SEVA plasmid collection [1] were selected as a backbone. To ensure the stability of the plasmids, the HOK/SOK toxin-antitoxin system was introduced into the SEVA plasmids 221 and 251 resulting in pSEVA221 and pSEVA251 . The obtained plasmids were compared in a stability experiment: for pSEVA251 , 100% stability could be achieved, even after 100 generations.
In order to equip the SEVA251 plasmid with TCE degradation capacity, TCE degradation genes were isolated from the pTOM plasmid originating from Pseudomonas putida G4. These genes, together with a constitutive promoter, are cloned into pSEVA251 . In the final step, the complete plasmids (including the degradation genes) are transferred to the growth-promoting endophyte Pseudomonas putida W619, which can be used for inoculation experiments. In future work, the pSEVA251 can be equipped with other desired degradation genes after which the entire plasmid can be transferred into the desired endophyte.

Reference: [1] R. Silva-Rocha et al. (2013) Nucleic Acids Res. 41 (D1): D666-D675.

Keywords: endophytes, phytoremediation, biodegradative plasmids

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171. Wilson, Jordan

Phytoscreening for Vapor Intrusion Potential:
Comparing Effects of Tree Diameter

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Phytoforensics has been shown to be a cost- and time-effective tool in qualitatively delineating groundwater contaminant plumes as contaminants translocate into trees from groundwater the vapor phase in the vadose zone; however, little is known about how tree characteristics (such as tree species, size, and age) affect sampling results. Considerable unknowns include the subsurface volume sampled by plants and plant responsiveness to subsurface contaminant changes. To investigate how tree diameter affects tree contaminant concentrations, tree coring was used at a Superfund site contaminated primarily with perchloroethylene (PCE) in Missouri. As part of tree-core and soil sampling, over 300 tree-core samples and about 900 soil samples were collected over 7 and 35 days, respectively. Paired samples, which consist of tree cores from pairs of large- and small-diameter trees in close proximity, were collected from 18 tree pairs. Phytoforensics was about 5 times quicker than soil sampling, about an order of magnitude less expensive, and encompasses a larger environmental volume with each sample. Phytoforensics also improved pollutant delineations by accurately indicating the presence of two PCE "hotspots" shown by traditional soil samples along with a third hotspot that would not have been found without sampling the trees. Paired study results indicate that, even after diffusive loss adjustments, PCE concentrations were significantly lower in smaller-diameter trees than in large-diameter trees, suggesting differences in subsurface sampling characteristics (e.g. subsurface sampling volume).

172. Włóka, Dariusz

The investigation of the organic and mineral fertilizers efficiency in the process of PAHs bioremediation in soil

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The aim of the research was to investigate the efficiency of the mineral and organic fertilizers in the process of bioremediation of polycyclic aromatic hydrocarbons (PAHs) in soil. The scope of undertaken actions includes the pre-analysis of soil and four formulations of studied fertilizers, the three-months incubation and the final determinations of pollutants content in all analyzed samples. The whole experiment was hold on in controlled conditions by using phytothrone chamber. The used fertilizers were composed from the organic waste materials (sewage sludge, composts) and mineral sorbents. As an results of performed research the following occlusions has been observed: the introduction of organic fertilizers in the form of sewage sludge or compost produces a short-term increases in the efficiency of organic pollutants bioremediation in soil. The addition of mineral sorbents, as a sewage sludge and compost immobilization agent has a significant impact on the effective action time of this type of fertilizers.

Keywords: Soil pollutants, Polycyclic aromatic hydrocarbons (PAHs), bioremediation, sewage sludge

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173. Wu, Longhus

Phytoextraction of cadmium contaminated agricultural soils using hyperaccumulator Sedum plumbizincicola: pot and field study

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Pot and filed studies were conducted to investigate the phytoextraction of Cd contaminated soils using hyperaccumulator Sedum plumbizincicola. The results of successive phytoextraction experiment of four contaminated soils using S. plumbizincicola over three years in a glasshouse showed that total and extractable Cd concentrations in soils after phytoextraction were all greatly decreased, and Cd removal efficiency was much higher in the acid soils than calcareous soils. The phytoextracted Cd mainly came from acid soluble, reducible and oxidisable forms based on BCR fractions. Cd desorption rate constants in all remediated soils were significantly decreased based on the model of DGT-induced fluxes in soils (DIFS). Moreover, most of (88-99%) the removed Cd came from the coarse ones when considering the weight distribution of soil particles, although the decreases in fine particles were higher than in coarse ones. The field study in an acid red paddy soil showed that S. plumbizincicola removed 301 and 353 g Cd hm-1 from the soil in 2013 and 2014, respectively. After two years' remediation soil Cd concentration decreased form 0.64 mg kg-1 to 0.22 mg kg-1 (the permission levels of China is 0.3 mg kg-1) and rice grain Cd concentrations of two cultivars decreased by 85% and 46%, respectively, compared to the untreated soil. We conclude that phytoextraction of Cd using the hyperaccumulator S. plumbizincicola was a promising technique for the remediation of Cd slightly to moderately contaminated agricultural soils especially acid soils.

Keywords: acid soil, cadmium, hyperaccumulator, phytoextraction, Sedum plumbizincicola

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174. Wu, Qi-Tang

Mechanisms in Low Accumulation and High Tolerance towards Cadmium of Cultivars of Brassica parachinensis

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Cultivars significantly different in Cd-accumulation and tolerance of Brassica parachinensis were screened out. Lvbao-701, being low-accumulating and high-tolerant cultivar, was compared with a high-accumulating cultivar, Chixin-4, in order to elucidate mechanisms involving in the low-accumulation of Cd in crops. Root cell walls were separated by a method dissolving the cytoplasm with organic solvent, Cd concentrations and phytochelatins (PCs) in plant roots were measured. Furthermore, the phytochelatins synthase (PCS) gene was cloned and expressed under Cd stress. Results showed that Lvbao-701 had significantly higher content and proportion of Cd combining with cell wall in roots (56% - 77%) than Chixin-4 (26% - 54%). These proportions of Cd combining with cell wall in roots were higher than that obtained previously with conventional grinding method. Cd stress induced Lvbao-701 to produce more PCs and it resulted higher PCs content in Lvbao-701 than in Chixin-4. Cloning and expression of cDNA fragment of phytchelatin synthase (PCS) gene from Brassica parachinensis (BpPCS1) indicated that, in both Lvbao-701 and Chixin-4, BpPCS1 was expressed mainly in roots, and was induced by Cd. The BpPCS1 expression in roots of Lvbao-701 was higher than that of Chixin-4. Therefore, keeping a large amount of Cd in root cell wall and producing more PCs in roots were probably the main reasons for Lvbao-701 to have a lower Cd translocation to shoots and a stronger tolerance to Cd than other cultivars.

Keywords: Cadmium (Cd), Brassica parachinensis, Accumulation, Tolerance, Genotype difference, Mechanisms, Phytochelatins synthase gene

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175. Yang, Junxing

Phytoaccumulation of heavy metal (Pb, Zn,Cd) in ten wetland plants under different hydrological regimes

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Wetland plants have been widely used in constructed wetlands for the clean-up of metal-contaminated waters. This study aimed to investigate the rate of radial oxygen loss (ROL) of roots, metal (Pb, Zn, Cd) uptake, iron (Fe) plaque formation, and their relationships in various wetland plants under flooded and non-flooded conditions. A pot trial with metal-contaminated soil was conducted to apply flooded and non-flooded conditions using ten emergent wetland plants. Significant differences were found in biomass, rates of ROL, metal (Pb, Zn, Cd) uptake and Fe plaque on root surface and in the rhizosphere of the ten plants under flooded condition compared to non-flooded condition. The results indicated that the plants tested on average produced more biomass, rates of ROL, metal (Pb, Zn, Cd) uptake and iron (Fe) plaque on root surface and in the rhizosphere of the ten plants under flooded condition compared to non-flooded condition. In addition, wetland plants with higher rates of ROL were tended to have higher biomass, Fe plaque and metal adsorption on the roots and in their rhizosphere under flooded conditions than those under non-flooded condition. These results suggested that ROL may play an important role in biomass and Fe plaque formation and heavy metals (Pb, Zn and Cd) adsorption in rhizosphere of wetland plants under flooded condition.

Keywords: heavy metal, wetland plant, flooded and non-flooded conditions, iron plaque, radial oxygen loss

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176. Yang, Xiyan

Phytoremediation of Heavy Metals Assisted by Plant Growth Promoting (PGP) Bacteria: A Review

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Continued industrialization, agricultural practices, and other anthropogenic activities lead to heavy metals contamination. Heavy metals have severe toxic effects on plants, animals, and human health, and therefore their remediation is crucial. Among the various techniques used, phytoremediation is one of the safest, most innovative, and effective tools for the remediation of heavy metals. Phytoremediation of toxic metals and metalloids has been reported by researchers using a variety of plants. The efficiency of phytoremediation can be enhanced by the assistance of Plant Growth Promoting (PGP) bacteria. These bacteria transform metals into bioavailable and soluble forms through the action of siderophores, organic acids, biosurfactants, biomethylation, and redox processes. In addition, PGP bacteria possess growth-promoting traits, including phosphorus solubilization, nitrogen fixation, iron sequestration, and phytohormone and ACC (1-aminocyclopropane-1-carboxylic acid) deaminase synthesis, which improve plant growth and increase plant biomass, in turn assisting phytoremediation. Our current review of the literature highlights the potential of PGP bacteria, which facilitate phytoremediation of heavy metals in contaminated areas.

Key words: Hyper-accumulating plants, Heavy metals, Phytoremediation, PGP bacteria, Symbiosis.

178. Yaseen, Muhammad

USE OF TEXTILE WASTE WATER AS ORGAINC AMENDMENT FOR PRODUCTION OF WHEAT ON SALINE SODIC SOILS

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Disposal of industrial waste water is a burning issue of urbanization. However, this problem can be sorted by using waste water as alternate source of irrigation. In this way, problem of disposal not only will be resolved but also scarcity of irrigation water can be kept off in future. Before using industrial waste water as source of irrigation, however, there is need to investigate whether it is environment friendly or harmful. A field experiment was conducted for investigating whether industrial waste water can be beneficial for wheat production or not. Treatment plan included canal water, bleaching waste water, printing waste water and end drain waste water along with and without liquid NPK fertilizer. Findings revealed that application of disposed water from bleaching, printing and end drain water without liquid NPK fertilizers cause negative effect on wheat crop but application along with NPK fertilizers positively affected growth and yield of wheat, however, produce was inferior to that of control qualitatively as application of waste water accelerated uptake of different heavy metals. Moreover, results also indicate that application of water disposed from bleaching unit caused comparatively less uptake of heavy metals compared to water disposed from end drain and printing units.

Keywords: heavy metals, textile, wheat, waste water, Waste water amendment, liquid NPK

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179. Yasin, Muhammad

Selenium toxicity in cereal crops and its detoxication by Se resistant microbes

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Selenium (Se) is not essential for growth of higher plant but it can be toxic for plants if its concentration is high in soil. Selenium occurred naturally in soil worldwide and its concentration is highly variable in different regions of world, most of soils contain between 1.0 and 1.5 mg Se kg-1 of Soil. In this study, we tested phytotoxic effects of elevated levels of Se (3 mg kg-1 of soil) on corn plant growth, biomass production and leaf enzymatic content. Microbial community present in rhizosphere of plant can play an important role to stimulate plant growth and improve tolerance against various abiotic environmental stresses. Plants were inoculated with Se resistant bacterial strains YAK-1 (Genbank acc # JX203248, showed 99% homology to Bacillus foraminis strain) to observe the effects of inoculation on plant growth as well as on Se toxicity. Such a high concentration of Se in soil resulted in significant decrease in plant biomass and shoot length (33%) and significant increase in leaf acid phosphatase activity compared to non Se-treated control plants. Strain YAK1 exhibited high resistance against Se (up to 20 mg sodium selenite mL-1 of LB media) and showed plant growth promoting characteristics; mixed organic acids production, ammonia production and hydrogen cyanide (HCN) production. In the absence of Se, bacterial inoculation resulted in increased plant biomass and leaf acid phosphatase activity. Interestingly when Se-treated plants were co-cultivated in the presence of bacteria, plant shoot length increased significantly compared to only Se-treated plants. Under Se supplemented condition Se content were significantly enhanced compared to untreated control plants. In conclusion, high concentration of Se in soil showed toxic effects on corn growth and may be potentially toxic for other cereal crops, and inoculation with Se resistant rhizosphere bacteria can possibly alleviate Se toxicity in cereal crops.

Key words: Selenium, heavy metal resistance, Plant-microbe interaction, PGPR.

180. Zaghloul, A. M.

Valuation of certain remediative amendments in enhancing phytoremediation in various contaminated soil ecosystems

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After building of Grand Ethiopian Renaissance Dam (GERD), significant drastic shortage in Nile water resources in Egypt is predictable. This situation of water shortage would force Egyptian farmers to use low quality water resources impregnated with a variety of contaminants that will inserted in food chain. In a complete randomized plot design greenhouse experiment, soil samples collected from Abou-Rawash, Sinai and Kafr El-Shekh Governorated irrigated with varied types of low quality waters for extended periods were trailed for the sake of valuation of new innovative phytoremediation practices. In the used three soil ecosystems, the Zn equivalent parameter, that indicates the safety of cultivation, ranged between 340 and 630, while the safe level should not exceed 250. Integrated management practices were applied using canola and Indian mustard hyper accumulator plants, in association with Acidithiobacillus thiooxidans and Arbuscular Mycorrhiza (AM) after furnishing the soil ecosystem with the chemical stabilizer of PTE's probentonite. Results indicated that the canola hyper accumulator plant was more efficient than Indian mustard plant especially in Ni uptake compared to Cu or Zn uptakes. In addition, the introduction of Acidithiobacillus thiooxidans and AM to the contaminated soil ecosystems significantly enhanced the uptake of PTE's. The kinetic parameters of both theoretical and empirical models confirmed that the mixture of all remediative amendments was the best in minimizing Zn equivalent value to a save level. The different mechanisms that might take place between the applied remediative amendments and PTE's in the three contaminated soil ecosystems were discussed.

Key words: Zn equivalent, Kinetic models, PTE's, Soil ecosystems, Sewage effluents, Acidithiobacillus, Mycorrhiza.

181. Zaghloul, A. M.

Chemical characterization of Sewage Effluent repetitively used in arid soils irrigation

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Sewage effluent samples were monthly collected during the period from January to July 2012 from the main canals of Konbora (Abu-Rawash site) and Zenine (El-Motamadia site) that are frequently used in irrigating different eaten raw field and horticulture crops. Nile water samples were periodically collected from El-Khanater El-Khayria as standard irrigation water. The chemical characterization of sewage effluent and Nile water samples included pH, conductivity, SAR, soluble cations as well as potential toxic elements (PTEs) using standard analytical methods. Results confirmed significant variations in these studied chemical parameters between the two studied sewage effluents. A significant increase in EC, pH and SAR values in both sewage effluents samples compared Nile water, representing save levels for irrigation water according to FAO standards, were noticed. The content of PTE's in both sewage effluents showed that the concentrations of Cd2+, Cu2+, Mn2+ and in some months and those of Zn2+ in certain months far exceeded the safe levels found in Nile water. Despite that the Doneen parameter, that estimates water quality (Cl- + 0.5 SO42) should not exceed 5 in irrigation water, both sewage effluent samples had values higher than the safe level. Special precautions and remediation biotechnologies should be considered to minimize health and environmental hazards for such waters.

Key words: sewage effluent, PTE's, Abu-Rawash and Motamadia sites.

182. Zalesny, Ronald

Long-term monitoring of poplars used for phytoremediation

Ronald S. Zalesny Jr.*, U.S. Forest Service Northern Research Station; William L. Headlee, Iowa State University; Gayathri Gopalakrishnan, Space Science Institute; Edmund O. Bauer, U.S. Forest Service Northern Research Station; Richard B. Hall, Iowa State University; Dennis W. Hazel, North Carolina State University; J.G. Isebrands, Environmental Forestry Consultants; Louis A. Licht, Ecolotree, Inc.; M. Cristina Negri, Argonne National Laboratory; Elizabeth Guthrie Nichols, North Carolina State University; Donald L. Rockwood, University of Florida; Adam H. Wiese, U.S. Forest Service Northern Research Station

Poplars are ideal for phytotechnologies, especially those integrating biomass production with ecological restoration. Poplars exhibit fast growth, extensive root systems, and elevated water usage, all of which are necessary for effective phytoremediation. However, not all poplars perform the same across variable soil, climate, and contaminant conditions. In fact, their tremendous genetic variability allows for selection of superior clonal material based on genetic- and site-related factors, as well as how specific genotypes respond to such stimuli. In addition to this need for selection, an equally-difficult challenge for phytotechnologies is the commitment and ability to continue measurements and monitoring throughout the rotation. In the current study, we have evaluated long-term phytoremediation sites from the standpoint of how genotypic selection influences the provision of ecosystem services such as biomass productivity and carbon sequestration of trees ranging in age from 5 to 15 years. In total, we sampled 15 poplar plantings from 11 phytoremediation systems located in the Midwest (Illinois, Iowa, Wisconsin) and Southeastern United States (Florida, North Carolina), testing 54 clones belonging to 10 genomic groups. In this presentation, we will highlight results from these long-term monitoring and assessment efforts from very different sites along the urban to rural continuum, with contaminants of concern ranging in complexity from salts to petroleum hydrocarbons. We will focus on these differences within the context of provisioning (e.g., biomass, water) and regulating (e.g., carbon, soil quality, erosion control) ecosystem services and the need for a cleaner environment during times of accelerated ecological degradation.

Keywords: biomass productivity, carbon storage, field tests, phytotechnologies, Populus

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Preferred Format: Oral

183. Zalesny, Ronald

Biochar soil amendments enhance early hybrid poplar establishment

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Biochar is a co-product of pyrolysis oil production from biomass that has shown benefits as a soil amendment for hybrid poplars. For example, Headlee et al. (2014) reported that biochar provided similar benefits to hybrid poplar clone 'NM6' in terms of nutrient availability and growth when substituted for vermiculite in greenhouse production. The overarching objectives of the current study were to evaluate survival and growth of poplar genotypes when grown in biochar-amended soils, compared to soils containing vermiculite or no amendments, and to test whether effects from greenhouse production remained when trees were outplanted to the nursery. Our specific objectives were 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) poplar 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. Overall, considerable variability among genotypes in their responses to the soil amendments were observed, while field survival and nutrient effects were consistent with short-term greenhouse results (i.e., greenhouse testing can be used to predict outplanting success). Also, vector analysis was conducted to diagnose the biological significance of tree responses to the soil treatments, and improved availability/uptake of some nutrients with biochar and vermiculite treatments was demonstrated.

Headlee, W.L., Brewer, C.E., and Hall, R.B. 2014. Biochar as a substitute for vermiculite in potting mix for hybrid poplar. BioEnergy Research 7:120-131.

Keywords: biomass, clonal selection, Populus, plant uptake, phytotechnologies

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Preferred Format: Oral

184. Zeeb, Barbara

Phytoremediation of Salt and Hydrocarbon Impacted Soils Using Biochar Augmentation

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Salinization of soils can often occur concurrently with petroleum hydrocarbons (PHCs) in oil producing and processing areas. Plants including ox-eye daisy (Leucanthemum vulgare), alfalfa (Medicago sativa), and yellow clover (Melilotus officinalis) have shown promise as rhizodegraders of heavy hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs). Biochar which is produced by the thermal decomposition of organic matter, sequesters carbon dioxide, improves plant growth and assists in phytoremediation. In this project, we demonstrate the use of rhizoremediation and biochar to concurrently remediate hydrocarbons and reduce the effects of a saline environment on plants. Greenhouse studies using hydrocarbon and salt impacted soils were undertaken. Alfalfa, yellow clover, tall wheat grass (Agropyron elongatum), Nuttall's alkali grass (Puccinellia nuttalliana), and inland salt grass (Distichlis spicata) were grown in soils with and without 2.5% (w/w) biochar. Soils were monitored for hydrocarbon contamination levels over a three month period. Plant growth and health were measured throughout the studies and compared to controls. A comparison of plant health and growth between the different species and contaminants used in the greenhouse will be presented, and the effects of biochar on hydrocarbon degradation will be discussed.

Key words: petroleum hydrocarbons, salt contamination, rhizoremediation, excretory halophytes

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186. Zhao, Xin

Comparison of the influence of Cd, Ni and Cu on Sunflower growth and accumulation capacity

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Some plant species (i.e. Helianthus annuus) can extract heavy metals from contaminated soil and accumulate the heavy metals in their aboveground biomass. Heavy metal concentrations in soil affect the plant growth and their accumulation in plants. In this study, sunflower seeds were sown and grown in various heavy metals contaminated soils to monitor the biomass productions and heavy metal accumulation capacities of sunflowers. Cadmium, nickel and copper were selected as target heavy metals. Each heavy metal concentration in soil was set according to the seedling vigor index (SVI) of results from previous seed germination tests. There was no significant difference ($P > 0.05$) in biomasses of sunflower grown in soils contaminated with lower concentrations (SVI = 600) of Cd, Ni and Cu. There was no seed harvest in higher concentrations (SVI = 150) of Cd contaminated soil due to the high toxicity. The heavy metal accumulation capacities of sunflower generally increased as heavy metal concentrations increased in the soil within the range of which plant growth can withstand. Within the range, liner relationships can be expressed between the heavy metal concentrations and the mass of heavy metal uptake by sunflower. The translocation factor (TF) values of the target heavy metals were less than 1. However, the bioaccumulation factor (BF) values of Cd in the sunflower were greater than 1 while BF values of Ni and Cu were less than 1. This indicates that sunflowers have good phytoextraction potentials for the removal of Cd compared to Ni and Cu from contaminated soils.

Keywords: bioaccumulation factor, heavy metal, sunflower, translocation factor
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Acknowledgement: This work is supported by the Korea Ministry of the Environment as "The GAIA (Geo-Advanced Innovative Action) Project".

187. Zia-ur-Rehman, Muhammad

Comparative response of maize hybrids to cadmium stress with respect to growth and different micronutrients uptake

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Cadmium (Cd) is a non essential element, highly toxic at very low concentrations for plants and animals. It enters the agricultural soils mainly through anthropogenic activities such as industrial processes, sewage sludge and phosphate fertilizers. Cadmium causes several biochemical and physiological disorders in plants and animals. A number of strategies are available to minimize Cd load in edible parts of the plants. The cultivation of low Cd accumulating varieties/ hybrids seems the most promising strategy to reduce Cd accumulation in the edible parts. A hydroponic experiment was conducted to evaluate different maize hybrids response to growth and micronutrients uptake under Cd stress. Seven maize hybrids were grown with increasing levels of Cd (0, 05, 10 and 15 µM) in the form of Cd(NO3)2 in nutrient solution for 20 days. Maize plants exposed to 15 µM Cd exhibited substantial reduction in root and shoot growth in all the hybrids. The reduction in root and shoot biomass of DKC 6525 and Moncento 919 was less as compare to other hybrids. Minimum Cd uptake was recorded in DKC 6525 and Moncento 919 in both root and shoots. Cd stress decreased the uptake of Zn, Cu and Mn while increased Fe concentration in maize root and shoot. We concluded that increasing Cd levels in hydroponics decreased maize growth interfering photosynthetic activity as well as by restricting the availability of micronutrients and plant response varies with maize hybrids. Among different hybrids, DKC 6525 and Moncento 919 hybrids proved as low Cd accumulators.

Key words: phytoavailability, cadmium, maize hybrid, low accumulation

188. Zulfiqar, Asma

Chromium (IV) uptake of crambe and the resultant changes induced by Cr stress in photochemical responses, antioxidant activity and lipid peroxidation.

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Chromium (Cr) contamination has a particular concern of developing country having enormous and severe implications for the animal and plants life. Crambe abyssinica Hochst. ex R. E. Fries, a memeber of Brassicacea family is naturally tolerant to heavy metals. It is a high biomass, oil- seed and non –food crop. The potential of crambe for Cr tolerance has been evaluated on assessing the photosynthetic efficiency and activity of different antioxidants enzymes by exposing it with 150µM concentration of Potassium chromate (VI) in a time dependent study. Cr stress resulted in significant decline in photochemical efficiency (Fv/Fm) only in delayed Cr treatment. Quantum yield of leaf (Fs/ Fms) exhibited a decline initially in the beginning of Cr-treatment, readjusting to some extent with passage of time and again exhibiting a significant decline in later stages. An increase in Superoxide dismutase (SOD) activity was observed in later stages of chromium exposure in root while it remained constantly lowered than control plants in leaf for the whole duration of experiment. Root APX and GPX also showed the same trend as that of leaf. Both enzymes showed a resistant to Cr stress in whole seedlings.CAT activity remained high all along while in roots it increased in later stages of chromium exposure. Lipid peroxidation showed a gradual increase with increased duration of Cr (VI) exposur.

Keywords: Chromium; Phytoremediation; Antioxidants Enzymes; Lipid peroxidation; Crambe abyssinica.

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POSTER ABSTRACTS

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POSTER ABSTRACTS

P1. Adejumo, Sifau A.

Heavy metal accumulation in metallophytes as influenced by the variations in rhizopheric and non-rhizopheric soils physico-chemical characteristics

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The activities taking place at root-soil interface have been described as the major factors determining the behaviour of hyperaccumulators and non-hyperaccumulators under heavy metal stress conditions. A study was conducted to determine the rhizopheric soil physico-chemical characteristics and heavy metal distribution in different fractions as related to metal uptake by different plant species inhabiting lead-acid battery wastes contaminated site. These plant species were collected together with their rhizopheric soils and the soil from surface and sub-soil of non-vegetated portion of the site were used as control. Organic and inorganic functional groups present in the rhizopheric and non-rhizopheric soils were also investigated using FTIR (Fourier Transmittance Infra-Red). Higher concentration of Pb was found in non-rhizopheric soil compared to rhizopheric soils. A reduction in pH and electrical conductivity values were observed in all the rhizopheric soils. Nutrients such as organic carbon, P and DOC were also more at the rhizopheric soils. Pb was mostly stored in the organic fraction of rhizopheric soil and residual fraction of non-rhizopheric soil. Conversely, Lower concentrations of heavy metals were generally found in the soluble and exchangeable fractions of rhizopheric soils compared to other fractions and non rhizopheric soils. Among the plant species found on this site, Eleucine indica accumulated the highest Pb concentration both in the shoot and root followed by Gomphrena celosoides. More pronounced peaks of C-O and O-H functional groups were also found in the rhizopheric soils compared to non-rhizopheric soils.

Keywords: Rhizophere, Contamination, Heavy metals, Metal speciation, Metal accumulators

P2. Arachchige, Pavithra Pitumpe

Effect of long term agricultural management practices on soil carbon sequestration

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Soil carbon (C) sequestration has been identified as one of the effective potential mitigation option for increasing atmospheric CO2 concentration. Climate, mineralogy and agricultural management practices affect soil organic C (SOC) content, chemistry as well as SOC stabilization mechanisms. This research is focused on understanding the SOC sequestration based on management practices and aggregate fractions by determining chemistry of SOC, SOC and mineral associations/interactions.

Soil samples were collected from North agronomy farm, Manhattan, KS (0-5 cm depth). This site was under 22 years of corn and had two tillage treatments (tilled/no-tilled), two fertilizer treatments (manure/chemical fertilizer) and a control. Four water stable aggregate sizes were separated by wet sieving. Amorphous iron (Fe) and total organic C (TOC) were determined. Composite soil samples were used for bulk-NEXAFS and 13C NMR studies.

Manure added soils exhibited significantly higher concentration of amorpous Fe. Amorphous Fe and TOC were strongly correlated in some aggregate sizes. In-situ NEXAFS analysis and 13C NMR revealed that manure addition influences on labile (aliphatic) C stabilization. No-till management showed significantly higher labile C in macroaggregates. There seems to be possible high degree of C stabilization in manure added soils.

Outcome of this study will provide useful information on mechanisms of SOC preservation in soil aggregates responsible for the differences in their resilience. In addition, these results will be a great addition to the bigger picture in recognizing the management practices with greater potential of soil C sequestration which will be useful in suggesting mitigation options for greenhouse gas offsets.

Keywords: agriculture, manure, no-till, C stabilization

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P3. Asimi, Oyas Ahmed

IMMUNOMODULATORY AND GROWTH RESPONSE OF L.ROHITA TO DIETARY FORTIFICATION OF CLOVE AND/OR CARDAMOM EXTRACT

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Though antibiotics provide a useful means to control many bacterial diseases but development of antibiotic resistance is a major problem. As an alternative, feeding many plant extracts through diet protects the fish against chronic oxidative stress-related diseases (Sakai, 1999). Many plants contain different compounds in their natural extracts, generally rich in antioxidants (El Saleh, Al Sagair and Al Khalaf, 2004). Enormous reports are available regarding the immunomodulatory role of different plant extracts in fish (Al Jishi, and Abuo Hozaifa, 2003).

In this context, it was hypothesized that fortification of these spice extracts in fish feed, which exhibited good antioxidant activity, must have immune-modulatory properties. Hence, the extracts of clove and cardamom were taken as isolation or in combination to study the growth and immune-modulatory effect in a tropical fish L.rohita, which has not been reported elsewhere. Methods:- Extraction of spices, Growth performance, Challenge study, Sampling, Determination of superoxide anion (NBT), Total serum protein, albumin and globulin, Lysozyme activity, Plasma superoxide dismutase (SOD), Catalase (CAT), Statistical analysis.

Present study was conducted to evaluate the immuno-modulatory and growth response of clove and/or cardamom extracts in the diet of L.rohita.. The solvent extracts (ethyl acetate) of clove and cardamom were selected based on the highest antioxidant properties and antimicrobial activities exhibited by these two extracts out of eleven commonly used spices screened for the same. Both the spice extracts were mixed separately or in combination at the level of 0.5 and 1.0%. Thus, six experimental diets were Cl-0.5%, Cl-1.0%, Cd-0.5%, Cd-1.0%, C.C-0.5% and C.C-1.0%. Highest growth rate ($P<0.05$) was recorded in the Cl-0.5 group. Hepatosomatic index (HSI), gastro somatic index (GSI) and protein efficiency ratio (PER) was also highest ($P<0.05$) in Cl-0.5 group. Lowest mortality was recorded in the Cl-0.5 group after challenged with Aeromonas hydrophila. It can be concluded that clove extract at 0.5% in the diet promotes growth, enhances antioxidant activity and protects the immunity of L.rohita challenged against A.hydrophila.

P3A. Arowojobe, Yemisi

Biosorption of Lead from Aqueous Solution using Avocado Pear (Pearsea americana) Exocarp

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This project was carried out to assess the potentials for the removal of lead ions from aqueous solutions using Avocado pear exocarp (Pearsea americana). Effects of various parameters such as solution pH, contact time, biosorbent particle sizes, biosorbent dose and temperature profile were investigated. Results obtained show that Pearsea americana exocarp was 98% effective in removing lead from aqueous solution at an optimum pH of 4 in 30mins contact time. The sorption of lead followed pseudo-second-order kinetic model. This was further supported by intra-particle diffusion and Elovich models. Two isotherms viz: Langmuir, Freundlich were used to analyze the equilibrium data and the equilibrium sorption data fitted into the isotherms with Langmuir having the highest R2 value. The results also show that the sorption capacity increased with decrease in particle size and increase in biosorbent dose, while it decreased with increase in solution temperature. From the experimental results, Pearsea americana exocarp could be used as a biosorbent for the treatment of water and wastewater contaminated with lead ions.

Keywords: Avocado pear exocarp, biosorption, lead, adsorption isotherms

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P4. Atagana, Harrison

Biological removal of cyanide from contaminated soil by using Chromolaena odorata

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This study measured the toxicity of cyanide to Chromolaena odorata at 50, 100, 200 mg kg-1 in contaminated soil by measuring changes in the transpiration rates and respiration rates of the plants, and the ability of the plant to remove cyanide from the contaminated soil after growth for 100 days was also measured. The effect of rhizosphere populations in transforming cyanide before plant uptake was also studied. The results showed that between 5 and 15% cyanide was metabolised during the period of growth in the experimental soil whereas 2.3% was metabolised in the control experiment. Accumulation of cyanide in the plant tissues was between 5 and 7% of the contamination level in the soil. The study showed that at 50 mg kg-1 soil, there was 27.5% reduction in transpiration and 15% reduction in respiration. However, at 100 and 200 mg kg-1, reduction in transpiration and respiration were not significantly higher than was observed in the 50 mg kg-1 experiments. Overall, cyanide was removed from the soil by between 73.4% and 92.7% in all the experiments. The rhizosphere organisms inoculated into the soil converted some of the cyanide into intermediate compounds which were transported through the plants or accumulated in some other forms that were not measured in the plant tissues. While the concentrations of cyanide tested in this study affected the transpiration and respiration of the plants, the potential to remediate the contaminated soil was demonstrated.

Keywords: Chromolaena odorata, cyanide, degradation, rhizosphere organisms, soil.

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P5. Aulakh, Karanbir

Understanding the regulation of TAG biosynthesis in Arabidopsis thaliana Karanbir Aulakh*, Timothy Durrett, Department of Biochemistry and Molecular Biophysics, Kansas State University, Manhattan KS, USA TAGs are major storage lipids found in developing seeds, petals, pollen grains, and fruits of various plants. TAGs play an important role in the development, growth and reproduction by serving as lipid and energy reservoirs. In Arabidopsis thaliana seeds, DGAT1 is the major enzyme contributing to TAG biosynthesis. However dgat1 mutants retain 60-80% seed TAG content due to involvement of PDAT1 in acyl-CoA independent TAG biosynthesis. This study focuses on the elucidation and functional characterization of novel genes involved in the regulation of the TAG biosynthesis pathway in plants. In both Col-0 WT and dgat1-1 lines, lipid profiling was carried out for different seed developmental stages (8-16 DAF). In developing dgat1-1 mutant seeds, altered fatty acid composition was observed with reduced TAG content and increased polar lipid content as compared to Col-0 WT. We performed RNA-Seq of developing Arabidopsis seeds to detect differentially expressed genes in dgat1 compared to Col-0 WT. RNA-Seq detected 28,642 protein-encoding genes and 35298 transcripts. EDGE (Empirical analysis of Differential Gene expression) test revealed significant differentially expressed genes among all developmental stages in dgat1-1 compared to Col-0 WT. The number of differentially expressed genes for each developmental stage were filtered with p-value correction (<0.001) and fold change (>=2). Significant changes in gene expression profile were detected in lipid related genes such as oleosins, desaturases and elongases. RT-PCR was used to confirm the differential expression of major lipid related genes (DGAT1, PDAT, FAD2). Further validation of differentially expressed genes will be done by RT-PCR followed by functional characterization.

Keywords: Arabidopsis, oil synthesis, transcriptional profiling, DGAT1

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P6. Bahadar, Khalida

Management of Bipolaris sorokiniana the causal pathogen of spot blotch of wheat by Eucalyptus extracts

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The inhibitory effect of essential oil of flowering buds and potential fractions of most effective extracts of Eucalyptus camaldulensis Dehn and Eucalyptus torelliana F. (leaf, Bark and Flowering Buds) were evaluated on the most aggressive isolate of Bipolaris sorokiniana from wheat crop by agar well diffusion, food poison technique and macro-dilution assay. The mycelial growth was evaluated over four periods (3; 6; 9 and 30 days from incubation) with nine concentrations of essential oils (0.5%; 01%; 2.5%; 05%; 7.5%; 10%; 15%; 50%; 100%) and three concentrations of effective fractions (01%; 05% and 10%). E.oil showed a maximum zone of inhibition of 90 mm diameter and mycelia growth 0.00±0.00 compares to control 40.00±0.00 after 9 days of incubation at 100% concentration. The extracts of F. buds showed the strongest active values ($P < 0.05$) with a 29.10±0.92 ZOI compared to water extract (19.80±0.33). The ethanol and methanol fruit extracts showed highest minimum inhibitory concentration (08mg/mL) than water extracts (200mg/ml) against B. sorokiniana, while minimum fungicidal concentration values for ethanol and methanol fruit extract 40 mg/mL and water extract 300 mg/mL. Extract treated hyphae were collapsed, damaged or thinner when compared with the control. This Study reveals that, F. buds were the potential part of plant. The E.oil and ethanol fractions of F. buds were consider most effective that shows considerable potency (up to 90% in-vitro inhibition) than the bark and leaves solvents extracts, while no inhibitory effect was noticed for the aqueous extract of leaves and bark in combating the pathogen.

Key words: Eucalyptus, Aqueous and organic solvent extracts, essential oil, Biopolaris Sorokiniana.

P7. Barabasz, Anna

Cd/Zn supply-dependent modification of the expression of metal-homeostasis genes in tobacco expressing AtHMA4

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Engineering high shoot content of Zn/Cd for phytoremediation includes modification of processes controlling metals root-to-shoot translocation. Expression of export protein AtHMA4 (involved in loading Zn/Cd into Arabidopsis root xylem vessels) in tobacco, however, failed to yield one set pattern of Zn/Cd accumulation/distribution at varying metal levels in the medium. Detected in transgenic plants Zn/Cd supply-dependent Zn/Cd accumulation/distribution results from modification of the endogenous metal cross-homeostasis network of the host plant due to transgene expression.
To address these phenomenon SSH-based analysis was performed to look in transgenic plants for differentially expressed Zn/Cd cross-homeostasis genes (relative to wild-type). Noteworthy, all identified genes (NtZIP1, NtZIP2, NtZIP4, NtIRT1-like, NtNAS, NtVTL, NtMTP1A) were shown to be up-regulated by Zn-deficiency which was proposed to be related to Zn-deficiency status resulting from constant export activity of AtHMA4 in transgenic tobacco. Their expression upon exposure to a range of reciprocal combinations of Zn and Cd was than examined, and Zn/Cd/Fe accumulation. In the wild-type, transcript levels depended on the concentrations of Zn/Cd in the medium, but expression of AtHMA4 modified these patterns. The most remarkable differences were shown for NtZIP1, NtZIP2, NtIRT1-like, NtVTL, and NtMTP1A. However, NtVTL was the most responsive gene in wild-type and transgenic plants, thus it seems to be crucial for the generation of metal supply-dependent accumulation of metals in transgenic plants.
In general, our results contribute to understanding molecular mechanisms underlying the Zn/Cd-supply-dependent effects of a transgene on Zn/Cd root/shoot partitioning. This knowledge is crucial for successful modifications for phytoremediation purposes.

Keywords: AtHMA4, cadmium, tobacco, zinc, transformation

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P8. Bartels, Katherine

Green Roof Leachate Water Quality

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Green roofs provide many benefits such peak flow attenuation, runoff reduction, and increased roof life expectancy. However, green roofs require nutrient-containing media capable of sustaining vegetation. Nitrogen, potassium, and phosphorous are common nutrients in fertilizers present in commercial green roof medias to promote plant growth. Nitrogen (N) and phosphorous (P) are also limiting nutrients in bodies of water; excess N and P can lead to eutrophic and anoxic conditions, which may result in inhibiting aquatic life, including fish kills.

Water leaching from green roof media carries nutrients from the building and often enters nearby water bodies, potentially contributing to eutrophication. Organic carbon and suspended solids (TSS) are of concern in urban stormwater as well. Excess organic carbon in water leads to greater oxygen demand, further depleting oxygen. Introduction of suspended solids contributes nutrients to the water body, as the nutrients are sorbed to the solids and may dissolve once in solution. For accurate valuation of green roof systems, excess nutrient, carbon and solids contributions to urban waters should be assessed.

Three cylinders filled 3" deep with green roof media: GAF, Arkalyte, and one control of Thermoplastic Polyolefin (TPO), performed in triplicate, were used in an in-vitro study simulating typical precipitation events. Results demonstrated a decrease to steady state of N, P, TSS, and organic carbon in green roof leachate over time for the different media tested. Methods developed for assessing water quality were established and can be utilized in assessing the impacts of green roofs on urban waters.

Keywords: green infrastructure, eutrophication, nitrogen, phosphorous,

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P9. Belwal, Tarun

Optimization of Extraction Methods for Phenolic and Antioxidants Activity in Berberis Asiatica Fruits Using Response Surface Methodology

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Wild fruits are known to play significant role in preventing free radicals mediated diseases. This property is largely due to the phenolics and other metabolites present in the fruits, which are reported to have strong antioxidant activity. Considering to this study was designed to optimize the extraction of phenolics and antioxidants in Berberis asiatica fruits using response surface methodology (RSM). Solvent selection was done based on the preliminary experiments and a three-level-five-factor, Central Composite Design (CCD) consisted of 46 experiments was conducted to analyzed the effect of extraction temperature (X1: 30 – 80°C), extraction time (X2: 30 – 90 min), sample to solvent ratio (X3: 1:10 – 1:50), pH of the solvent (X4: 3 – 5) and solvent concentration (X5: 20 – 80 %) for extraction of total phenolic (TPC), anthocyanin (TAC), tannins (TTC), flavonoids (TFC), and antioxidant activity [2,2-azinobis-3-ethylbenzthiazoline-6-sul- phonic acid (ABTS), Ferric reducing antioxidant power (FRAP), and 1, 1-Diphenyl-2-picryhydrazyl (DPPH)]. Results revealed that extraction temperature (X1), sample to solvent ratio (X3) and solvent concentration (X5) significantly influenced response variables and independent variables. The regression coefficient (R2) was found satisfactory for all the models except for DPPH response. The lack of fit was found non-significant ($p>0.05$) for TPC, TAC, TTC and TFC indicating that the models could adequately fit the experimental data. Response surface analysis showed that under optimal extraction conditions the phenolic antioxidant extraction maximized. Similarly, the corresponding response values for TPC, TAC, TTC, TFC were 4659 mg GAE/100g dw, 219 mg CGE/100g dw, 1850 mgTAE/100g dw, 0.63 mg QE/100g dw and for antioxidant activities ABTS, FRAP, DPPH were 2721, 36487, 1685 mM AAE/100g dw, respectively at the optimal condition. These values are in accordance with the predicted values, indicating the success of RSM in optimizing the extraction conditions. This method can be used further for scaling up nutraceutical and pharmaceutical applications and also can be implemented in other fruits of the region for harnessing their potential in commercial sector.

P10. Bolatkhan K.

Biotesting various contaminated aquatic ecosystems based on the Mutant test strains of microalgae

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There are some difficulties to control the content of toxicants in the environment by chemical methods, in addition, the physiochemical methods of indicating the status of the environment do not give a direct answer to the question about the possible response of ecosystems to these or other contamination. Due to the high sensitivity of the algae to the environmental conditions, they play an important role in bioassay methods. One of the major advantages of using unicellular eukaryotes as test objects is the high rate of reproduction, which allows the laboratory to observe the cell population for many generations, and accordingly get a quick response to the presence of toxic and mutagenic substances. In this study, the method of induced mutagenesis derived mutant of Chlamydomonas reinhardtii (CC1021), named as CC1021Mut1 - mutant obtained in photoautotrophic conditions, characterized by light green color. The bioassay of water samples from two different bays of Lake Balkhash (Torangalyk and Baytal) using pigment cells of the mutant green microalgae Chlamydomonas reinhardtii CC1021Mut1 in order to obtain a more complete assessment of the ecological status of the lake. The results indicate the presence of toxic substances in concentrations that do not have a toxic effect on the growth of a strain of Chlamydomonas reinhardtii CC1021Mut1. The study of water samples taken from the two bays of Balkhash Lake by using bioassay methods with mutant strain Chlamydomonas reinhardtii CC1021Mut1showed a medium degree of water pollution from these sources.

Keywords: Biotest, microalgae, mutant strains, ecosystem, wastewater

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P11. Bradfield, Scott

Influence of TiO2 Engineered Nanoparticles on Photosynthetic Efficiency and Contaminant Uptake

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The majority of plant-nanoparticle interactions are currently focusing on the direct negative effects of nanoparticles on the health of the plant; however the current research aimed to determine if TiO2 engineered nanoparticles (ENPs) could be beneficial for plants via two different strategies. Firstly, determination whether the foliar application of TiO2 engineered nanoparticles and/or bulk TiO2 on Zea mays elicited a positive response in terms of photosynthetic efficiency. Physiological parameters (net photosynthesis, transpiration, stomatal conductance, and internal leaf temperature) were recorded to determine the effects of TiO2 on photosynthesis. Previous research with spinach has shown that the foliar application of TiO2 may increase several parameters associated with photosynthesis. However, these studies were performed for short time periods in controlled environments. The current study examined the effects of TiO2 ENPs and bulk material on Z. mays under natural settings. Secondly, efforts were made to determine the influence of TiO2 ENPs on the uptake and accumulation of cadmium and arsenate by broccoli plants. The underlying thought was that if the contaminants became adsorbed to the surface of the TiO2 ENPs, it would restrict the uptake or the bioavailability of the contaminants. Restriction of inorganic contaminant bioavailability via ENP-contaminant interactions may reduce the toxicity of a contaminated soil by limiting the amount of the inorganic contaminant that is freely available for the plants to take up and accumulate.

Keywords: nanoparticles, titanium dioxide, photosynthesis, inorganic contaminants

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P12. Chandra, Rachna

Kinetics and equilibrium of copper ion removal

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We investigated the potential of red soil to adsorb Cu(II) from aqueous solution by batch experiments. At pre-determined times, the samples were removed from the rotary agitator and filtered immediately before being analyzed for Cu(II) content. Influences of adsorbent dosage and adsorbate dose on Cu(II) adsorption were also examined. The kinetic process of Cu(II) adsorption on red soil was described by applying pseudo-first-order and pseudo-second-order rate equations and it was inferred that the process obeyed pseudo-second-order rate equations (R2 = 0.999). The results obtained from batch experiments were fit into Langmuir, Freundlich and Temkin isotherms. The equilibrium adsorption data were better fitted to the Freundlich adsorption isotherm model. The experiments showed that highest removal rate was 94.9% for Cu(II). The red soil investigated in this study exhibited a high potential for the removal of Cu(II) from aqueous solution.

Keywords: Adsoprtion, Copper, Freundlich, Isotherms, Red soil

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P13. Chandra, Rachna

Removal of nickel from aqueous solution using black soil

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High concentrations of heavy metals in the environment are detrimental to a several species. Concerns by environmentalists on the impact of heavy metals on the environment have resulted in increased research in developing advance technologies to remove these heavy metals. Nevertheless, a few studies concentrated on the natural potential of environmental matrices. In the present work, investigation on the effect of contact time, adsorbent dosage and metal ion concentration on Ni(II) adsorption from aqueous solution was carried out using black soil. While isotherm studies were used to model the adsorption process.

The kinetic process of Ni(II) adsorption on black soil was described by applying pseudo-first-order and pseudo-second-order rate equations. The experimental data were analyzed using the Langmuir, Freundlich and Temkin isotherms. The experiments showed that highest removal rate was 72.16% for Ni(II). The kinetic data for the adsorption process obeyed pseudo-second-order rate equations (R2 = 0.999). On the basis of experimental results, it is inferred that the black soil has a high natural potential for the removal of Ni(II) from aqueous solution.

Keywords: Adsoprtion, Nickel, Freundlich, Isotherms, Black soil

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P14. Chaturvedi, Ritu

Phytoremedial potential and Inventory of heavy metal transporters in Ricinus communis L. and Solanum lycopersicon L.

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In order to survive under metal stress condition, plants have developed adaptations including alteration in gene expression of metal transporters that are responsible for uptake, efflux, translocation, and sequestration of metal ions. Zn, Mn, Co, Cd, Pb, Cu, Cr, Ni and As levels were assessed in Ricinus communis and Solanum lycopersicon, members of Euphorbiaceae and Solanaceae at some of the industrial sites in Agra city. The range of these metals was also worked out keeping in view their level at different sites. Both of these plants exhibited good phytoremediation potential with Lycopersicon esculentum proving to be a phytoextractor for Cd, Cu, and As and phytostabiliser for Zn. Ricinus communis is identified as phytoextrator for Mn. The aim of this study is to interpret the genes conferring uptake, translocation and sequestration of heavy metals in Ricinus communis and Solanum lycopersicon, members of Euphorbiaceae and Solanaceae respectively, with their genomes sequenced in 2010 and 2012 respectively. It is noteworthy that genes leading to heavy metal tolerance have remained conserved in these plants. The genes responsible for heavy metal transport in Arabidopsis thaliana and Arabidopsis halleri have already been characterized. It can be interpreted that the homologs of metal transporters present in these plants and their regulation is responsible for their field potential. From the data obtained it can be interpreted that genes responsible for Zn transport and sequestration in R.communis and S.lycopersicon and for Cr transport in S.lycopersicon are overexpressed in roots as compared to their shoots.

Keywords: Phytoextraction, Phtostabilization, Heavy metal

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P15. Chien, Mei-Fang

Characterization of rhizobacteria isolated from arsenic hyperaccumulator ferns

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Since arsenic (As) is one of the most dangerous carcinogens and is harmful to plants, animals, and humans, remediation of As polluted soil and water is one of the major issue of concern in environmental science and public health. To resolve this issue, phytoextraction using (As) hyperaccumulator plants is a highly expected strategy. Previous studies suggest that As uptake by hyperaccumulators is largely determined by As speciation, which is strongly influenced by microbial activities.
To have a detailed picture of bacteria inhabit in the rhizoshpere of As phyperaccumulators, rhizobacteria of two As hyperaccumulator ferns, Pteris vittata and Pteris multifida, were investigated. Cultivable bacteria were isolated using rhizosphere samples of two ferns, and 112 bacterial strains with different morphologies and arsenic tolerance were isolated. These isolated strains were identified by determining their 16S rRNA gene sequence, and their minimum inhibitory concentration against arsenate and/or arsenite, As oxidation and/or reduction ability, plant growth promoting ability and re-colonization ability to the rhizosphere were investigated. As the results, some isolates which belonged to Actinobacteria and β-Proteobacteria showed highly As(III) oxidation activity, and the rhizosphere re-colonization of some isolates belonged to β-Proteobacteria were also confirmed. These results helped linking microbial activity to phytoextraction by As hyperaccumulators and gave hints when designing pre-treatment procedures of phytoextraction.

Keywords: arsenic, arsenic hyperaccumulator , rhizobacteria, phytoextraction

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P16. Dar, Amara

Phytofilteration: A Green approach for water treatment

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Industrial effluents are responsible for injecting organic pollutants in water sources. These organic pollutants are non-biodegradable, persistent in the environment and equally harmful for both animals and plants. Toxicity profile of these pollutants clearly prevail their carcinogenic and lethal nature. Phytofilteration have been proved to be a promising method for removal of such pollutants from water that is used for both drinking and agricultural purposes. Chemically and thermally treated phytosorbents have been prepared and used for the removal of organic pollutant from water. Various parameters like agitation speed, contact time, pH, and phytosorbent dose were optimized. More than 90% of the removal efficiency has been attained using capsules of the locally available plant generally called berri patta. Isothermal and kinetic modeling of the study further revealed the effectiveness of the water treatment process.

Keywords: Phytofilteration, organic pollutants, water treatment

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P17. Davis, L.C.

Boron uptake is regulated in sunflowers

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We have investigated the impact of boron (B) and salts on growth of sunflowers using a hydroponic system. Relatively high B levels are present in flue gas desulfurization water (FGD water), a highl salts waste stream of coal-fired power plants. Sunflowers tolerate levels of calcium, magnesium, sodium, sulfate and chloride like those found in typical FGD water, with moderate decrease of growth. Added B inhibits growth and produces necrosis of older leaves where it accumulates. We measured both water use and dry mass gain. The ratio of water use/dry weight gain (~350-400 mL/g.d.wt) is constant at different levels of salt and B, but total biomass is decreased by high B. If B accumulated proportional to water uptake, the levels in plants would vary proportionally with concentration in the nutrient solution. That is not the observed result. At high external B (10-20 mg/L) the concentration within the plant is only 300-400 mg/kg dry wt, rather than 4-8,000 mg /kg.d.wt., expected of passive uptake. Plants grown with 0.25-0.5 mg/L B, accumulate the expected 70-150 mg/kg dry wt. Active uptake of B under deficiency conditions and efflux under excess have been reported in a few B-sensitive plants. Our results show that sunflowers can strongly exclude B despite the small size and neutral character of B(OH)3 for which rapid diffusive influx through membranes and extracellular spaces was expected. If uptake is regulated, it can be engineered, indicating potential for crops highly resistant to B toxicity. This has large implications for areas such as the Central Valley of California where B toxicity is a limiting factor for crop production.

Acknowledgments: Burns and McDonnell's Kansas City Office is thanked for discussions and financial support. Supported in part by the Kansas Agricultural Experiment Station

Key words: boron toxicity, salts, sunflower, flue gas desulfurization water

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P18. Devi, Sarita

Salinity tolerance in halophytes by maintaining ionic contents

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Six species of halophytes viz. Arundo donax, Atriplex amnicola, Atriplex lentiformis, Atriplex nummularia, Haloxylon recurvum and Heliotropium rammossimum were grown in salinity microplots (1.25m length X 1.25m breadth X 1m depth) to study their tolerance behaviour against the salinity stress. Before sowing the desired levels of salinity i.e. 8 and 16 dSm-1 were maintained. The sampling was done at early flowering/maximum vegetative stage. The cumulative shoot length was decreased from 8 to 16 d Sm-1 of salinity and maximum was noticed in Atriplex lentiformis (91.49 cm). A reverse trend was observed in dry shoot biomass, ash content, total dissolved solids and ranging from 1.20 to 2.29 kg m-2, 201 to 485 mg g-1 dry mass, 1.34 to 4.40 mg L-1. Total phytoaccumulation of ions per unit area was found maximum in Atriplex lentiformis (1989.98 mg m-2) and least was found in Arundo donax (883.77 mg m-2). On the basis of physiological traits and phytoaccumulation of ions Atriplex lentiformis was found best salt hyperaccumulator.
Keywords: Salinity, Halophytes, Tolerance and Hyperaccumulator
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P19. Dixit, Garima

Sulfur attenuates arsenic toxicity by efficient thiol metabolism and antioxidant defense system in rice

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Globally, many regions are arsenic (As) contaminated with South East Asia being worst affected. Rice is major crop in this region posing serious health risks due to its known As accumulation potential. Sulfur (S) is an essential macronutrient and a vital element to combat As toxicity. Current study was planned to investigate role of S vis-a-vis As toxicity under different S regimes (0.5 to 5 mM) in rice. High sulfur condition resulted in high root As accumulation probably due to As complexation through enhanced synthesis of thiolic metabolites such as non protein thiols and phytochelatins and restricted its translocation to shoot. Enzymes of S assimilatory pathway and downstream thiolic metabolites were up regulated with high S supplementation, however, to maintain optimum level of S, transcript levels of sulfate transporters were up-regulated as lower S response. Oxidative stress generated due to As was counterbalanced through HS condition by reducing H2O2 level and enhancing antioxidant enzyme activities. High sulfur level results in reduced transcript level of Lsi2 which is correlated to low shoot As accumulation due to reduced translocation and has implications in possible reduced risk of food chain contamination.

Key words: Antioxidant enzymes, Arsenic, Rice, Sulfate and Arsenic transporters, Sulfur, Thiol metabolism.

P20. Dong, Jing

The effect of Funnelliformis mosseae Inoculation on alleviating Atrazine damage to Canna indica L. var. flava Roxb.

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Atrazine is a photosynthesis inhibiting triazinic herbicide. Atrazine is considered as a relatively persistent chemical in the environment and it induces damage to plants. We investigated the effect of Funnelliformis mosseae inoculation on atrazina-treated Canna indica L. var. flava Roxb.. In the range of 0-15 mg L-1 atrazine, the growth of Canna showed a negative relationship with atrazine concentration while inoculating with Funnelliformis mosseae played an active role in the growth. The chlorophyll content increased at first and decreased subsequently with the increase of atrazine level, and inoculating with Funnelliformis mosseae increased the chlorophyll content. CAT ,SOD and POD activities were induced by atrazine, while Funnelliformis mosseae inoculation alleviated the oxidative stress. The root activity showed a declining trend with the increase of atrazine level, although inoculating with Funnelliformis mosseae increased the activity in the range of 0-10 mg L-1 atrazine but it had no singnificant effect on the root activity in 10 and 15 mg L-1 atrazine. The remove rate of atrazine by Canna was significant which accounted for 30.8-100% at different atrazine concertration in a 14 days experiment, and inoculating with Funnelliformis mosseae increased the romove rate. In conclusion, Funnelliformis mosseae inoculation alleviated atrazine damage to Canna indica L. var. flava Roxb. and promated the biodegration of atrazine. Canna indica L. var. flava Roxb. with Funnelliformis mosseae inoculation plays a dominant role in reducing the atrazine level in the water body and could be used as phytoremediation candidates.

Keywords: atrazine, Funnelliformis mosseae inoculation, Canna indica L. var. flava Roxb., alleviat, damage, remove rate

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P21. Elgharably, Ahmed

Wheat growth and uptake of Cu, Zn, Cd and Pb in a soil amended
with city trash, or farm yard manure with rock phosphate

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Organic matter and P compounds are able to bind soil metals. Enrichment of soil with organic matter or rock phosphate could protect plants against metal pollution. The study aimed to investigate the effects of 2% city trash (CT) and 2% farm yard manure (FYM) added separately or with 0.2% rock phosphate (RP) on wheat growth and uptake of Cu, Zn, Cd and Pb. Soil, treated with wastewater over 50 years, was collected from the area of El-Madabegh, Assiut. Soil total concentrations of Cu, Zn, Cd and Pb were approximately 607, 1557, 10.3 and 123 mg kg-1 soil, respectively.
Highest wheat dry matter was recorded for the soil treated with the mixture of FYM and RP. With no amendments added, wheat roots accumulated approximately 38, 98, 36 and 51 mg and wheat grains accumulated approximately 11, 70, 33 and 41 mg kg-1 dry matter of Cu, Zn, Cd and Pb, respectively. Lowest concentrations of Cu, Zn, Cd and Pb were found in the grains. The amendments led to decreased heavy metal content in wheat roots, shoots and grains, and this decrease was best expressed with 0.2% RP and 2% FYM. Lower heavy metals uptake by wheat was notable with addition of FYM compared to CT. Organic amendments added with rock phosphate were especially effective for reduction of cadmium and lead contents in wheat grains.
Combined addition of organic and inorganic amendments is more effective than addition of inorganic or organic amendments alone in reducing wheat uptake of Cu, Zn, Cd and Pb.
Keywords: amendments, city trash, heavy metals, rock phosphate, wheat

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P22. Gonzalez, Rogelio Carrillo

Extraction procedure and chemical composition of two plants for Green synthesis of Ag nanoparticles

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Synthesis of dispersible silver nanoparticles (AgNP) has been done successfully using chemical reactants; however the use of toxic chemicals is an environmental concern. Green synthesis represents a friendly alternative to produce them, but there is still scarce information about procedure of extraction and environmental conditions related to size and stability of AgNP. Aqueous extracts from Foeniculum vulgare and Tecoma stans were used for synthesis of AgNP. The extracts were obtained by water infusing and by vapour extraction process in a distillation system. Nanoparticles were synthesized mixing these plants extracts with 2, 3 and 5 mM of AgNO3 solution at 40 and 80 oC. Nanoparticles were characterized for size, form, protein content, UV visible and IR spectroscopy. Silver reduction peak was confirmed by colour change and variation in the absorbance plasmon resonance at 495 and 490 nm for F. vulgare and T. stans, respectively. The best temperature for infusing the plants was at 80 oC. The procedure for plant infusion does not affect the geometrical form of the nanoparticle, but the size does. Protein concentration was higher in the infusing solution than in the vapour extract. F. vulgare extract had higher protein concentration than T. stans extract. Size AgNP from F. vulgare was of 72 to 104 nm when synthesized by infusion and of 39 to 56 nm by vapour extraction method. While in T. stans, sizes of AgNP were 44 to 46 nm and 91 to 367 nm, respectively. A sort of functional group were involved in the AgNP synthesis.

Keywords: Foeniculum vulgare, Tecoma stans.

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Phytoextraction of Lead from Contaminated Urban Soil by Switchgrass Enhanced with Phytohormone, EDTA, Benomyl and Citric Acid

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Lead (Pb) contamination in soil represents a threat to human health. Phytoextraction of Pb contaminated urban soils in Atlanta, GA was tested by using Panicum virgatum L. (switchgrass) that was chemically enhanced with applications of the soil-fungicide benomyl, chelates (EDTA and citric acid), and phytohormones for phytoextraction. EDTA is often regarded as the most effective chelate, but has potential problems associated with its use due to long persistence time in soil and possible Pb mobilization into groundwater. Citric acid has been proposed as a possible alternative; however no consensus exists on its ability to generate similar phytoextraction without supplemental EDTA application. Application of citric acid, EDTA, benomyl, and phytohormone BAP were tested separately and in combination to determine the efficacy of phtyoextraction. Applications including EDTA (E+B+C and E+B+C+H) increased Pb concentrations in plant roots, but had no significant effect on Pb translocation into foliage. Application of citric acid without supplemental EDTA application was found to produce shoot Pb concentrations no different than those of plants treated with EDTA, indicating there was no benefit of EDTA application to translocation of Pb into foliage. Application of BAP was found to significantly increase root Pb concentration when combined with EDTA, citric acid, and benomyl (E+B+C+H), but did not result in increased translocation when combined with benomyl and chelates (B+C+H). Total Pb phytoextraction was greatest in plants treated with combined chemical application of B+C and B+C+H. Plants treated with E+B+C and E+B+C+H resulted in less total Pb extracted.
Keywords: citric acid, lead, phytoextraction, phytohormone BAP, switchgrass *Sigurdur Greipsson, 1000 Chastain road, Kennesaw, GA (sgreipss@kennesaw.edu)

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P23. Gonzalez-Chavez, Ma del Carmen A.

Arsenic concentration in wild plants from natural attenuation islands on two mine tailings

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Arsenic accumulation in wild plants naturally established in the contaminated area of Zimapan, Hidalgo, Mexico was studied. Total and EDTA-extractable As concentrations in the rhizosphere, in plants (shoots and roots) and deposition on leaves of eleven plants growing on two mine tailings (Santa Maria and San Francisco) were analyzed. Total soil As concentration ranged 4016 to 17,178 mg kg-1 while EDTA-extractable As was from 234 to 499 mg kg-1 for San Francisco and Santa Maria sites, respectively. The prevalent vegetation was: Vigueria dentata, Brickellia veronicifolia, Ruta graveolens, Dichondra argentea, Cuphea lanceolata and Aster gymnocephalus. As these plants may be collected from these polluted sites because of their use as traditional remedy of several illnesses, they represent a potential risk and pathway of entrance to human body. Similarly, some of these plants can be eaten by domestic animals living nearby the mine tailings. As shoot concentrations are higher than the maximum level tolerated by these animals (50 mg kg-1). A. gymnocephallus had the highest As shoot concentration (2,409 mg kg-1), bioconcentration (8.6) and translocation factors (9.6), and deposition of As in aerial part (7,521 mg kg-1). These values were independent of the soil As concentrations. In contrast, Dalea bicolor presented the lowest As shoot concentrations (52-88 mg kg-1) at San Francisco and Sta. Maria, respectively). Results also highlight that these plants functioning as As phytotraps as they are retaining high As concentrations on leaves surface. Hence, they strongly influence As dispersion and risk in mine tailings.

Keywords: As accumulation, translocation factors, As tolerant plants.
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P24. Greipsson, Sigurdur

Phytoextraction of Lead from Contaminated Urban Soil by Switchgrass Enhanced with Phytohormone, EDTA, Benomyl and Citric Acid

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Lead (Pb) contamination in soil represents a threat to human health. Phytoextraction of Pb contaminated urban soils in Atlanta, GA was tested by using Panicum virgatum L. (switchgrass) that was chemically enhanced with applications of the soil-fungicide benomyl, chelates (EDTA and citric acid), and phytohormones for phytoextraction. EDTA is often regarded as the most effective chelate, but has potential problems associated with its use due to long persistence time in soil and possible Pb mobilization into groundwater. Citric acid has been proposed as a possible alternative; however no consensus exists on its ability to generate similar phytoextraction without supplemental EDTA application. Application of citric acid, EDTA, benomyl, and phytohormone BAP were tested separately and in combination to determine the efficacy of phtyoextraction. Applications including EDTA (E+B+C and E+B+C+H) increased Pb concentrations in plant roots, but had no significant effect on Pb translocation into foliage. Application of citric acid without supplemental EDTA application was found to produce shoot Pb concentrations no different than those of plants treated with EDTA, indicating there was no benefit of EDTA application to translocation of Pb into foliage. Application of BAP was found to significantly increase root Pb concentration when combined with EDTA, citric acid, and benomyl (E+B+C+H), but did not result in increased translocation when combined with benomyl and chelates (B+C+H). Total Pb phytoextraction was greatest in plants treated with combined chemical application of B+C and B+C+H. Plants treated with E+B+C and E+B+C+H resulted in less total Pb extracted.
Keywords: citric acid, lead, phytoextraction, phytohormone BAP, switchgrass
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P25. Greipsson, Sigurdur

Effect of Foliar-iron Application on Phytoextraction of Switchgrass

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The effects of foliar-iron (Iron (II) Sulfate Heptahydrate) application in combination with soil fungicide (benomyl) and a synthetic chelate (ethylenediamineteteraacetic acid, EDTA) on lead (Pb) phytoextraction by switchgrass (Panicum virgatum) was examined. Switchgrass was grown in Pb-contaminated (76 mg Pb kg−1) urban topsoil with the following treatments: (C) Control, (B) Benomyl, (E) EDTA, (F) Foliar-Fe, (BE) Benomyl + EDTA, (BF) Benomyl + Foliar-Fe, (FE) Foliar-Fe + EDTA, (BFE) Benomyl + Foliar-Fe + EDTA. Each treatment was replicated (n=4) and pots were arranged in a completely randomized design. Samples from both the shoots and roots were analyzed for element concentration (Fe and Pb) using inductively coupled plasma (argon) atomic emission spectroscopy (ICP-AES). Translocation-ratio of Pb in shoots to roots (TF) was significantly higher in plants treated with foliar-Fe, indicating a significant effect of foliar-Fe on Pb phytoextraction. Treatments with benomyl, EDTA, and foliar-Fe alone were not effective in increasing Pb uptake to the harvestable portion (shoots) of the plants. Plants treated with foliar-Fe maintained their shoot Pb concentrations while decreasing concentration of Pb in the roots. Foliar-Fe treatment was successful in increasing TF of Pb from roots to shoots, and should be explored further as a phytoextraction enhancement strategy. Additional research in regard to the use of foliar-Fe application to increase the TF of Pb in switchgrass is recommended especially under higher soil Pb level before initiating a pilot study in the field.

Keywords: EDTA, iron supplement, lead, phytoextraction, switchgrass
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P26. Guarino, Carmine

Integrated bioremediation system of a TPHs-polluted soil by using autochthonous bacteria and phytoremediation: in situ application at a former oil refinery

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Petroleum products are crucial components of our society and increasing number of sites seriously contaminated by hazardous organic contaminants causes a great threat to any ecosystem.
The removal of Total Petroleum Hydrocarbons (TPHs) could be an expensive process involving high energy consumption. Several studies show that the use of environmentally friendly treatments (i.e. bioremediation) is cost effective having also a positive impact on public opinion. Biodegradation carried out by indigenous microorganisms represents a major mechanism by which TPHs can be eliminated from the environment.

In this work, the effectiveness of a combined bioremediation system for the reclamation of a TPHs polluted soil in a former oil refinery in northern Italy, was evaluated. According to positive results achieved at laboratory-scale, a biological remediation process named IBS-ABR (Integrated Bioremediation System with Autochthonous Bacteria and Rhizo-microbiota) was applied in the field. The basic principle of this strategy is the stimulation of the aerobic biodegradation performed by the autochthonous bacteria associated to a bioaugmentation step with the indigenous bacterial consortium previously isolated and characterized in laboratory. The following phytoremediation step assisted with promoting growth bacteria and fungi led to achieve successful results. Taking into account average values, TPHs showed a reduction of 50% after landfarming and biostimulation, and a further drop of 40% after phytoremediation and bioaugmentation. These significant results suggest that the combination of different bioremediation technologies, previously selected according to the site-specific features, is an effective, innovative and sustainable approach for enhanced in situ bioremediation of TPHs in large field scale.

Keywords: in situ bioremediation; autochthonous bacteria; rhizo-microbiota; IBS-ABR; TPHs.

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27. Gulen, Hatice

CADMIUM-INDUCED ACCUMULATION AND CELL MEMBRANE INJURY IN STRAWBERRY PLANTS

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The effects of water-applied cadmium (Cd) treatments were investigated on strawberry (Fragaria x ananassa cv. Camarosa) plants. Cold stored seedlings were grown in perlite:torf:soil (1:1:1) mixture in a greenhouse. Four weeks after planting, plants were treated by Actagro (7-7-7) nutrient solution containing 0, 500 and 1000 mg/l Cd (CdSO4) during 8 weeks. Fully expanded leaf and roots were collected from the plants at the end of the treatments for the analyses of cell membrane injury, lipid peroxidation (Malondialdehyde, MDA content) and chlorophyll content here in. In general, Cd treatments caused a linear increase in cell membrane injury and MDA content in both leaf and root issues with increasing Cd concentrations. Root tissues were more injured than leaf tissues by Cd treatments. The accumulation of Cd in root of the plants was determined higher than leaf, which were parallel to cell membrane injury and MDA content. In addition Cd treatments significantly increased the chlorophyll contents of the leaf tissues in comparison to control plants.

P28. Guo, Lin

Metal storage in reeds from an acid mine drainage contaminated field

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Wetland plants such as Phragmites australis have been used to treat acid mine drainage (AMD) contaminated soil. However, the mechanism about metal accumulation and translocation in reeds was not widely reported. This study investigated metal (Fe, Al and Mn) uptake and metal storage location in reeds grown in five different sampling sites of an AMD field. As expected, the higher the soil metal concentration, the more metal content in the belowground organs of reeds. Reeds grown in soils with the highest levels of metals accumulated 0.16±0.04 mg/g Mn, 16.29±4.15 mg/g Fe and 1.31±0.22 mg/g Al in roots. Most of iron was sequestered in the roots while Al was transferred to the shoots of reeds. Histological staining found that most of the iron was sequestered in the exodermis while Al was also observed in the endodermis of roots. Al even entered the stele of roots grown in soil with higher Al levels. The epidermis, cortex and central cylinder of rhizomes were the main tissues for Fe and Al storage. The more metals in rhizomes, the stronger intensity of the staining was observed around the vascular systems of rhizomes. No structural difference was observed among reeds collected from different sites. Further studies may be needed to enhance the transfer of metals in reeds and increase the phytoremediation efficiency.

Keywords: acid mine drainage; reed; metal storage; histological; phytoremediation;

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P29. Hajabbasi, Mohammad A.

Remediation of an aged petroleum contaminated calcareous soil incorporated with sewage sludge by maize (Zea mays L.) in central of Iran

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Stimulating microorganisms in the root zone is a mechanism for degradation and thus remediation of petroleum hydrocarbons. In this study, sewage sludge mixed with a calcareous polluted soil and degradation of petroleum hydrocarbons in the root zone of growing maize (Zea mays L.) was measured. Maize was grown in three levels of sewage sludge (0, 2, and 5% w/w) under controlled conditions. At the end of the experiment, total petroleum hydrocarbons (TPH), microbial respiration and dry weight of roots and shoots were measured. The results demonstrated that maize 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. Application of sewage sludge improved microbial respiration and resulted in faster TPH dissipation especially in the presence of plants.

Keywords: petroleum-contaminated soils, phytostimulation, maize (Zea mays L.), sewage sludge.

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P30. Hajabbasi, Mohammad A.

Phytoremediation performance of barley by adding compost to petroleum hydrocarbon contaminated soil

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Phytoremediation maybe enhanced when soil is corporate with amendments. In this study compost was added to soil contaminated with petroleum hydrocarbons and barley uptake was tested in the initial stages of growth. Survey of effect of simultaneous use of compost and plant barley in reducing and eliminating petroleum hydrocarbons in the soil used in this experiment showed, Which plants in presence of compost in comparison with other plants in the compost composting plants in the absence of compost were grown, have better growth, more extensive root systems and better performance in the shoots. Thus, the use of compost can play an important role on increasing plant yield in the process of phytoremediation of contaminated soil.

Keywords: Compost, phytoremediation, polluted soils

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P31. Hajabbasi, Mohammad A.

Rhizodegradation of petroleum contaminated soil using of Piriformospora indica inoculated maize (Zea mays L.)

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Plant-based methods are very promising for the remediation of petroleum-contaminated soils. In this study, a rhizobox experiment was conducted to investigate whether inoculation with the root-colonizing fungus, Piriformospora indica, could further enhance the degradation of petroleum hydrocarbons in the root zone of maize (Zea mays L.). The rhizoboxes were subdivided into compartments of increasing distance to the roots of the experimental plants. After filling the boxes with soil from a petroleum-contaminated site, seedlings that had either been inoculated with P. indica or not were grown in the middle compartments of the rhizoboxes and grown for 64 days. Also plant-free treatment was included for control. The presence of roots strongly increased the counts of total and petroleum-degrading soil bacteria, respiration, dehydrogenase activity, water-soluble phenols and petroleum degradation. All these effects were also found in the soil adjacent to the middle compartments of the rhizoboxes, but strongly decreased further away from it. Inoculation with P. indica further enhanced all the recorded parameters without changing the spatial pattern of the effects. Inoculated plants also produced around 40% more root and shoot biomass than non-inoculated plants and had greener leaves. Together, the results indicate that the treatment effects on the recorded soil microbial and biochemical parameters including petroleum hydrocarbon degradation were primarily due to increased root exudation. Irrespectively of this, they show that maize can be used to accelerate the rhizodegradation of petroleum hydrocarbons in soil and that inoculation with P. indica can substantially enhance the phytoremediation performance of maize.

Keywords: rhizodegradation, rhizobox, endophyte, Piriformospora indica, petroleum-contaminated soil

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P32. Harbordt, Nicole

Presence and Transport of PPCPs in Soils Irrigated with Municipal Wastewater

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Municipal wastewater land application to managed forests is an important treatment and disposal practice globally, but the fate of PPCPs in largely unknown in these systems. This study evaluated the fate of pharmaceutical compounds (PPCPs) in forest soils at a municipal land application site in North Carolina, U.S.A. Prior work has detected PPCPs in groundwaters and surface waters at the site, but only half of detected PPCPs in groundwater were detected in surface waters indicating mitigation by forest soils. Soil cores were hand-augured at several depths along transects from land application to groundwater discharge to surface waters. Soil moisture, soil texture, percent organic carbon, pH, and pE were determined at depth intervals for each soil sample. Each soil sample was first extracted with deionized water to determine readily desorbed PPCPs. Remaining soils were then solvent extracted to determine residual PPCPs. Relationships between PPCP characteristics, Log Kow, and depth were evaluated.

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P33. Huang, Chih-Min

Investigation the ability of Bidnes pilosa seedlings absorbs copper for farmland phytoremediation

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Agricultural lands in Taiwan were contaminated by using Irrigation water that has heavy metal. Therefore, the production of crop containing high concentrations of heavy metals has been considered an important food safety issue. Bidnes pilosa is a common wild herbaceous plant in the agricultural land, it is widely distributed in the barren lands of low and medium altitude. The purpose of this experiment has investigated the ability of Bidnes pilosa seedlings absorbs copper. The 0.050g of Bidnes pilosa seeds were placed in different concentration (0, 20, 200ppm, Repeat three times, One way ANOVA, $\alpha < 0.05$) of Copper Sulfate solution for seven days, the seedlings had been dried for weighing biomass, and then analyzed the copper ions concentration after heating by using nitro-hydrochloric acid. (Perkin Elmer AAnalyst 400) The observed results indicated that the 0.1444mg (Biomass) of 20ppm experimental group seedlings was slightly significantly higher than the 0.1207mg of blank group seedlings. Besides, 0.0669mg of 200ppm experimental group seedlings was significantly lower than the blank group. The 210mg/kg (Cu2+/Biomass) absorbed of 20ppm experimental group seedlings was significantly difference with the 30mg/kg absorbed of blank group seedlings. Besides, the 1730mg/kg absorbed of 200ppm experimental group seedlings was significantly higher than the blank group seedlings.
Conclusion of the investigation showed that Bidnes pilosa seed still germinated in the copper ions solution, but biomass of growth would be affected by concentration level. Therefore, it would be accepted that Bidnes pilosa has ability of phytoremediation, when it grows in the copper contaminated agricultural lands.

Keywords: Bidnes pilosa, copper, agricultural lands, phytoremediation

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P34. Jitto, Ponlakit

Toluene Removal and Decomposition by Epipremnum aureum (Lind. & André) Bunting

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Epipremnum aureum (Lind. & André) was climber with ability to absorb various volatile in air pollution.The objective of this research were studies toluene removal efficiency and adsorption capacity by using E.aureum (Lind. & André) Bunting leaf. And study change of morphology on plant leaf of plant before and after treat. The experimental plants are 8 week olds. Leaf area index of plant was chosen proximally 150 cm2. The result was showed that initial toluene concentrations of experiment range 0.865 to 17.3 mg/l. The toluene removal efficiency were 65.7-74.2 % then, the adsorption capacity range 14.36 to 292.49 µg/cm2. For Kondo plant adsorption model was found that, adsorption rate per initial toluene concentration of E. aureum was 0.0522 µg cm-2 h-1(µg/l)-1. The result of FT-IR technique found that toluene effected on the edge of upper epidermis more than middle of upper epidermis and lower epidermis, then the functional group of C=O (1735 cm-1), CC (1247 cm-1), CC (1025 cm-1), CH (1161 cm-1) and C-O-C (1064 cm-1) was decreased, while OH (3383 cm-1) was increased from the fresh leaf. The abnormal morphology of treated E. aureum leaf was found that the wax on cuticle of upper epidermis was destroyed, While benzene ring that indicated a toluene was not found on the leaf. Furthermore, needle shape of calcium oxalate and xenobiotic was found in spongy parenchyma cell.

Keyword: Toluene ; Air Pollution ; Phytoremediation ; Epiremnum aureum ; Xenobiotic

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P35. Kanso, Ali

Rhizosphere microbial activity in Technosols: an opposite effect of biochar and compost

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LORVER project, supported by Lorraine Region and European Union, aims to prove that abandoned industrial sites and materials are valuable resources to produce biomass for industrial purposes. We thus assessed the effect of two organic amendments (compost and biochar) on the microbiological and biochemical properties of a constructed Technosol during phytoextraction.
A Biocentre® treated soil was spiked with trace elements contaminated industrial sludges (BTS, 5% DW) and then amended with biochar (B2TS, 3% DW) or compost (BTSC, 3%DW). A three months greenhouse experiment was performed with planted (Noccaea caerulescens and Alyssum murale) and unplanted soils. Measured parameters were: soil physicochemical properties, plant growth, microbial biomass carbon (MBC) and nitrogen (MBN) and soil enzyme activities. MBC and MBN were significantly higher in BTSC soils without any plant effect, whereas MBN was significantly lower in cultivated B2TS soils. Mean microbiological biomass C:N ratios were not significantly different among non-cultivated Technosols and reached 19.7. In planted BTS and B2TS soils, this value significantly increased up to 41.5 and 106 respectively whereas it was not affected in cultivated BTSC soils. Fluorescein Diacetate and enzyme activities (urease, phosphatase and beta-glucosidase) were systematically higher in BTSC soils when measured per soil mass unit, whereas urease and phosphatase activities were higher in B2TS soils when values were normalized to MBC.
Technosols may have a low potential for microbial activity. If biochar strengthened nutrient limitations, compost alleviated them. Compost amendments could thus improve Technosols fertility and microbial activities linked with biogeochemical processes at both structural and functional levels.
Keywords: Compost, biochar, Technosol, enzyme activities, microbial biomass
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P36. Khalvati, Mohammadali

Phytoremediation (Plant-Microbe Interactions) Technology for Bioleaching Heavy Metals Contamination of Surface Soil in Industrial Area

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The amount of copper and glomalin-related soil protein (GRSP), a glycoprotein produced by two different species of arbuscular mycorrhizal fungi (AMF) G. intraradices and G. mosseae, its contribution to the sequestering of Cu in the soil, was studied in a copper polluted soil in greenhouse conditions. Rhizospheric (R) and nonrhizospheric (NR) soil of two representative plants (Sorghum bicolor and Helianthus annuus) associated with both mycorrhizal fungus were analyzed. The results showed a strong variability in GRSP (3.1–20.8 mg g−1), Cu content (20–80 mg kg−1 for the total Cu and 5.8–326 mg kg−1 for the available Cu) and pH (4.2–5.5) in the different plant and rhizospheric zones analyzed. A strong relationship between the GRSP with the plant root Cu contents was found (r=0.88 for Cu, pb0.001). This study provides evidence on the role of the GRSP in Cu and Zn sequestration and suggests a highly efficient mechanism of AMF to mitigate stress leading to stabilization of soils highly polluted by mining activities. Our data showed a strong relationship between G.mosseae mycorrhizal fungi and sunflower roots in terms of significantly uptake copper to the rhizosphere and furthermore transfer it to the shoot.

Key words: Soil, heavy metals, plant microbe, Glomalin
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P37. Khamis, M. Hesham

Efficiency of Melia azedarach and Populus alba to sustain contaminated soils by cadmium and lead

Vegetative growth, biomass, chemical content and uptake of cadmium (Cd) and lead (Pb) in Melia azedarach L. (chinaberry) and Populus alba L. (white poplar) seedlings were investigated using a 2-year pot experiment. The results indicated that Populus alba and Melia azedarach are tolerant to contaminated soil by Cd or Pb without any toxicity symptoms. Vegetative growth and chemical properties of Melia azedarach are negatively affected by Cd more than Pb whereas, biomasses are negatively affected by Pb little than Cd. Likewise, vegetative growth and chemical properties are negatively affected by Cd more than Pb however, biomasses are negatively affected by Cd and Pb with the same significant level. Both species accumulate more concentrations of Cd and Pb in their roots than in leaves and stem. As a result, Populus alba and Melia azedarach are considered suitable phytoextractors to sustain contaminated soils by Cd or Pb.

P38. Khan, Anisa

Enhancement of crude oil and heavy metal remediation by using a combination of Cynodon dactylon and Rhodococcus ruber

The major objective of this investigation was to evaluate the potential of native grass Cynodon dactylon, to clean up crude oil and heavy metal contaminants in soil such as lead (Pb), zinc (Zn), copper (Cu) and cadmium (Cd). For this, the plants were grown in an artificial soil system over a 90 day treatment period. Assessment of biomass in Rhodococcus ruber inoculated C.dactylon pots was carried out for a period of 90 days. The results showed a reduction of 74.68% of plant biomass, 79.7% of total petroleum hydrocarbons in T4 compared to control towards the end of experiment. The order of degradation of metals was found to be Pb>Zn>Cu>Cd. Our results indicate that C.dactylon in the combination of R.ruber can be employed for phytoremediation of crude oil and heavy metals in soil.

Keywords: Contamination, Crude oil, Degradation, Heavy metals, Rhodococcus ruber

P39. Kimes, Laura Brenner

Scaling Phytotechnology for Remediation and Stormwater Management: Applications and Observations

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Legacy cities throughout the Midwest and Northeast must deal with difficult problems: vacant and contaminated land, rising costs of stormwater infrastructure necessary to reduce sewer overflow events, and declining populations and tax base to pay for the necessary cleanup and infrastructure. To help solve some of these problems, Fresh Coast Capital plants phytoremediating hybrid poplar trees on vacant and contaminated land in a public-private partnership contract structure with cities and land banks. In this work, we present processes utilized in some of our spring 2015 tree farms and a planned spring 2016 phytoremediation site to demonstrate how scalable solutions to contaminated lands and stormwater can be applied in legacy cities. Developed as a business model that is part real estate company, part environmental engineering firm, and part impact investment fund, we believe this combination of expertise is necessary to solve this problem at a larger scale than has previously been achieved.

Keywords: hybrid poplar, brownfield, green infrastructure, stormwater, urban planning

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P40. Kiyawa, S.A.

Zinc Biosorptive Removal from Soils by some Selected Wild Flora in a Semi-Arid Region in Bagwai - Nigeria

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The objective of this research was to compare the potential of some selected wild flora for phytoremediation of Zinc. Levels of the metal in soils (S), and Flora (F) growing naturally were determined using atomic absorption spectrophotometer (AAS) (Alpha 4). Their Biological Concentration Factors (BCF) were also calculated. Whole plant tissues were used. These include: calotropis procera (F = 1.1053 µg/g, S = 1.1165 µg/g, BCF = 9.125). Commelina sp (F = 0.9179 µg/g, S = 0.3462 µg/g, CF = 2.651), Colocynthis bulgaris (F = 0.9504 µg/g, S = 0.2298 µg/g, BCF = 4.135), cucurbita pepo (F = 1.6529 µg/g, S = 0.3531 µg/g, BCF = 4.681), haemanthus sp (F = 1.0484 µg/g, S = 1.2291 µg/g, BCF = 0.853), hibiscus esculenta (F = 6.4265 µg/g, S = 1.0251 µg/g, BCF = 6.269), mitracarpus scaber (F = 0.7446 µg/g, S = 0.2381 µg/g, BCF = 3.127) and lactuca taraxacifolia (F = 1.3284 µg/g, S = 1.6038 µg/g, BCF = 3.284). The phytoremediation potential of the plants is in the order Calotropis procera > Hibiscus esculenta > Cucurbita pepo > Colocynthis bulgaris > Lactuca taraxacifolia > Mitracarpus scaber > Commelina sp.

Keywords: Bagwai, zinc, plants, Biosorption, phytoremediation.

P41. Kornacki, Catherine

Progress in the production of improved biofuels: Enhancing the production of acetyl-TAGs in a transgenic oil seed crop

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Using vegetable oils directly as an alternative biofuel presents several problems as such oils typically possess disadvantageous qualities including high viscosity, low volatility, and poor cold temperature properties. In nature, Euonymus alatus (Burning Bush) produces unusual acetyl-1,2-diacyl-sn-glycerols (acetyl-TAGs) that have an acetyl group in the sn-3 position instead of a long chain fatty acid. The presence of this sn-3 acetyl group gives acetyl-TAGs properties desirable for biofuels, such as a reduced viscosity, compared to normal long-chain triacylglycerols. The synthesis of these acetyl-TAGs is catalyzed by the Euonymus alatus diacylglycerol acetyltransferase (EaDAcT) and Euonymus fortune diacylglycerol acetyltransferase (EfDAcT) enzymes. Both enzymes catalyze the transfer of an acetyl group from acetyl-CoA to diacylglycerol (DAG) producing acetyl-TAGs. The transformation of EaDAcT in Camelina sativa resulted in seeds where 55 mol % of the triacylglycerol molecules were acetyl-TAGs. The sn-1,2-diacyglycerol acyl-CoA acyltransferase (DGAT1) enzyme competes with EaDAcT for their common DAG substrate. Expression of EaDAcT with suppression of DGAT1 in Camelina leads to seeds with 80 mol % acetyl-TAGs. We are currently exploring two different strategies to obtain even higher levels of acetyl-TAGs. First, we are expressing EfDAcT in Camelina. EfDAcT has demonstrated higher activity in vitro and its expression in yeast leads to approximately 50% higher levels of acetyl-TAGs compared to EaDAcT. Second, we are manipulating citrate lyase to increase the pool of acetyl-CoA to be used as a substrate for the acetyltransferase enzymes. We are currently analyzing the quantity and composition of acetyl-TAGs produced by the expression of different combinations of these enzymes in Camelina sativa seeds.

Keywords: biofuel, Camelina, seed oil, acetyl-TAGs, acetyl-CoA

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P42. Krygier, Richard

Using Willows for Shoreline Stabilization of End-pit Lakes Containing Oil Sands Process Affected Water

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In the Alberta oil sands, end-pit lakes are part of the overall reclamation plan after open-pit mining activities have been completed. As end-pit lakes are man-made structures constructed within the mined landscape, their shorelines are subject to erosion from wind and wave action. Given these lakes will be long-term features on the landscape; a natural, self-sustaining method of shoreline stabilization is being sought. One of the challenges is the inorganic (salt) and organic (naphthenic acid) components in oil sand process-affected water (OSPW) and mature fine tailings being experimentally treated in these lakes. Willows (Salix spp.) planted within the riparian area of these lakes may stabilize the shorelines provided they can tolerate OSPW.

Over 80 exotic and local willow clones were tested for tolerance to mixtures of OSPW and clean water using aeroponics chambers in a greenhouse. In the spring of 2014, 15 of the native willow clones exhibiting different levels of growth response in the greenhouse trial were planted along the edge of an end-pit lake containing OSPW. In both trials, survival and growth response varied not only between but within species. Early results indicate that the potential exists to collect, screen and utilize local willow clones for shoreline stabilization of end-pit lakes containing OSPW. These findings may also be applicable to soils impacted by salt seepages (downstream of riparian areas) originating from saline overburden, or from tailings pore water that migrates to the surface from soft tailings.

Keywords: oil sands, end-pit lakes, stabilization, shoreline, reclamation

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P43. Kumar, Amit

Selenium supplementation ameliorates arsenic induced oxidative stress through modulation of antioxidant enzymes and thiols in rice plant

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Arsenic (As) contamination of rice is a major problem for South-East Asia. In the present study, the effect of selenium (Se) on rice (Oryza sativa L.) plants exposed to As was studied in hydroponic culture. Arsenic accumulation, plant growth, thiolic ligands and antioxidative enzyme activities were assayed after single (As and Se) and simultaneous supplementations (As+Se). The results indicated that the presence of Se (25 µM) decreased As accumulation by 3-fold in roots and 2-fold in shoots as compared to single As (25 µM) exposed plants. Arsenic induced oxidative stress in roots and shoots was significantly ameliorated by Se supplementation. The observed positive response was found associated with the increased activities of ascorbate peroxidase (APX; EC 1.11.1.11), catalase (CAT; EC 1.11.1.6) and glutathione peroxidase (GPx; EC 1.11.1.9) and induced levels of non-protein thiols (NPTs), glutathione (GSH) and phytochelatins (PCs) in As+Se exposed plants as compared to single As treatment. Selenium supplementation modulated the thiol metabolism enzymes viz., γ-glutamylcysteine synthetase (γ-ECS; EC 6.3.2.2), glutathione-S-transferase (GST; EC 2.5.1.18) and phytochelatin synthase (PCS; EC 2.3.2.15). Gene expression analysis of several metalloid responsive genes (LOX, SOD and MATE) showed upregulation during As stress, however, significant downregulation during As+Se exposure as compared to single As treatment. Gene expressions of enzymes of antioxidant and GSH and PC biosynthetic systems, such as APX, CAT, GPx, γ-ECS and PCS were found to be significantly positively correlated with their enzyme activities. The findings suggested that Se supplementation could be an effective strategy to reduce As accumulation and toxicity in rice plants.

Keyword: Antioxidant, Arsenic, Oxidative stress, Rice, Selenium.

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P44. Kumar, Rakesh

Phytorid Technology: An improved Constructed Wetland System for Sewage Treatment

Rakesh Kumar*

Sewage generated in urban regions of developing countries is increasingly creating huge environmental burden. With limited installed capacity of treatment in centralised manner, a large portion of this sewage remains untreated and left as it is to water bodies. Sewage is being carried out from drainage systems and open channels (nallah) for past several decades in any urban settlement. These nallahs also serves as channels for storm water run-off. One of the major factor of failure of centralised conventional treatment is unavailability of continuous power supply and its high cost.In order to make the method feasible selection of technology for sewage treatment should be on criteria such as plant which works without electricity, require minimum maintenance and most importantly, the technology should be self-sustainable. In order to use the technology in rural areas these criteria become more important due to lack of skilled manpower and challenges on electrical supply. This necessitates use of natural methods, which are highly efficient and structured. Using this concept, natural wetland functioning has been used to design a technology wherein wetlands plants and combined working of their root system have been integrated to get a designer ecosystem. Phytorid technology development is based on natural method of treatment of sewage using constructed wetlands. This technology has been implemented and evaluated for its use for urban open drains flowing with sewage. It gives more than 90% removal for BOD and 60-80% removal of nutrients. The system has been evaluated also for its impact due to plants and flows variation. The footprint of the constructed wetland has been reduced below 1m2/m3 with retention time of less than 24 hours.

Keywords: phytorid, constructed wetland, sewage

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P45. Linton, James

Remediation of a 1,4-Dioxane Plume in a Fractured Rock Aquifer Using Engineered Phytotechnology – A Success Story

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1,4-Dioxane is a cyclic ether that was used as a stabilizer to prevent the degradation of chlorinated solvents during storage and use, at concentrations of up to 4% by volume. It is highly soluble (miscible) in water, highly stable and relatively immune to both abiotic and biotic transformation. 1,4-Dioxane tends to move in the groundwater at a higher rate than the associated solvents, and their breakdown products. These same characteristics also make 1,4-dioxane difficult to recover and treat. The general extent of the a dilute plume can require a significant extraction system to capture and contain the plume, and treatment systems designed to treat 1,4-dioxane generally require an aggressive (and expensive) component, such as ultraviolet photolysis or chemical oxidation.

The Site, located in Sarasota, Florida, employed chlorinated solvents in the manufacture or speed and proximity sensors during the 1970s through approximately 2008. An extensive, dilute 1,4-dioxane plume exists in a fractured limestone aquifer approximately 15 feet in depth. Contaminant recovery with an existing pump-and-treat system had become asymptotic; however, groundwater concentrations remained significantly above regulated levels, and would require many years of continued operation for remediation to be completed.
A Remedial Action/Optimization Plan that included the patented TreeWell® System was developed and implemented that enabled discontinuation of the existing system (with in excess of $300,000.00 in annual savings) approximately one year following installation. This presentation includes a discussion of regulatory hurdles and site conditions that were encountered and surmounted, and a discussion of data collected over three growing seasons.

Keywords: 1,4-dioxane, fractured rock, phytotechnology, optimization, TreeWell System

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P46. Liu, Xiaoyan

Phytoremediation effect of Sagittaria trifolia on diesel-contaminated sediment in estuary wetland

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It is significant to research phytoremediation effect of wetland plants along the estuary of Huangpu River, where oil spills had posed a threat to the sensitive coastal wetlands. Simulated experiment was used to investigate phytoremediation of diesel-contaminated sediment with Sagittaria trifolia, a dominant marsh plant. The results indicated that diesel had inhibitive effect on Sagittaria trifolia growth, when the diesel concentration was 20 000 mg/kg, the chlorophyll content was only 53.1% of control. Sagittaria trifolia significantly promoted diesel degradation in the sediment. After 50 days, 53.5-85.0% and 21.2-36.1% of diesel disappeared from the rhizosphere and non-rhizosphere soils respectively. The residual concentration of C20-C26 in the rhizosphere was lower than that in the non-rhizosphere, indicating that rhizosphere effect promoted the decomposition of long-chain alkanes. In the range of treatment concentrations, fungi quantity in the rhizosphere of Sagittaria trifolia was increased by 31.1% by lower concentrations of diesel contaminants, while bacteria and actinomycetes were inhibited even at the lowest concentration. Quantities of fungi, bacteria and actinomycetes were deduced by 32.7%, 60.0% and 66.0% respectively at 20 000 mg/kg diesel. Additionally, soil fertility was depressed with the increasing diesel concentrations. Significant positive correlations existed between chlorophyll content, microorganism quantity and the dissipation rate of diesel.

Key words: Wetland; diesel; phytoremediation; Sagittaria trifolia; rhizosphere

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P47. Luo, Jie

Phytoremediation Efficiency of Solanum Nigrum for Cd Polluted Soil Due to E-Waste Dismantling under Various Agricultural Technologies

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Phytoremediation efficiency of Solanum nigrum for Cd under various agricultural technologies in an e-waste dismantling site of Guiyu town has been evaluated. It was observed that N and P had little effect on remediation of Cd contaminated soil and K could slightly promote the remediation effect. NPK fertilized simultaneously can facilitate the remediation ability of Solanum nigrum significantly. Besides fertilization, appropriate planting density also enhanced phytoremediation effect significantly. The phytoremediation efficiency of Solanum nigrum under different harvesting methods was found in the following order: whole plant harvesting and replanting > partially harvesting and regrowing > harvesting in mature stage. The analysis of inclusion revealed that different agronomic practices could influence the effect of phytoremediation significantly.

Key words: phytoremediation; heavy metal; manage method

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P48. Luo, Yongming

Phytotoxicity of ZnO nanoparticles and the released Zn(II) ion to corn (Zea may L.) and cucumber (Cucumis sativus L.) during germination

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Toxicity of ZnO nanoparticles (ZnO NPs) on organisms is of concern worldwide due to their extensive use and discharge into the environment. Soil may be a major sink for engineered naoparticles released into the environment. ZnO NPs released into soil potentially have profound impacts on plants in terrestrial ecosystems. The impacts of ZnO NPs on seed germination and root elongation of corn (Zea mays L.) and cucumber (Cucumis sativus L.) were investigated on filter paper in Petri dishes. The role of seed coats of corn in the mitigation of toxicity and uptake of nanoparticles was also investigated. Results showed that ZnO NPs (1000 mg/L) exhibited no effects on germination, respectively, but reduced root length of corn and cucumber by 17 % ($p<0.05$) and 51 % ($p<0.05$). In comparison with Zn2+, toxicity of ZnO NPs on the root elongation of corn was attributed to the nanoparticulate ZnO, while soluble Zn from ZnO could solely contribute to the inhibition of root elongation of cucumber. Zn uptake in corn exposed to ZnO NPs during germination was much higher than in corn exposed to Zn2+, whereas Zn uptake in cucumber was significantly correlated with soluble Zn in suspension ($R=0.888$, $p<0.05$). It can be reasonably inferred that Zn was taken up by corn and cucumber mainly in the form of ZnO NPs and soluble Zn, respectively. Transmission electron microscope confirmed the uptake of ZnO NPs into root of corn. Although isolation of the seed coats might not be the principal factor that achieved avoidance from toxicity on germination, seed coats of corn were found to mitigate the toxicity of ZnO NPs on root elongation and reduced the Zn entering into root and endosperm.
Keywords: germination, nanoparticles, phytotoxicity, root elongation, seed coat
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P49. Majumder, Madhurina

The Potential of Pistia stratiotes Grown in Rice mill Wastewater to be Used as Fish Feed and Animal Forage
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Pistia stratiotes has been found to be effective in treating Rice mill wastewater and substantial growth of this plant has been observed. Suitable methods of disposal of this plant need to be evaluated and present study has been aimed towards this evaluation. Analysis of Pistia stratiotes grown in Rice mill wastewater has been done with respect to different parameters (crude protein, crude fibre, crude fat, ash content, total nitrogen, and total phosphorus). The proximate analysis has shown values of crude protein 5.69%, crude fibre 14.85%, crude fat 20.29%, ash content 18.75%, total nitrogen 0.91%, and total phosphorus 0.58%. The values of these parameters with those of various researchers have been compared and found to be close to each other. Little (1979) through his studies showed that aquatic plants serve as industrial raw material for paper making, biogas production, organic manure (compost) and fish feed formulation. Boyd (1967) conducted chemical analyses of the aquatic plants and observed that aquatic plants contain as much or more crude protein and mineral matter as conventional forage crops. Based on the findings of the different authors, present researcher has tried to establish the prospect of using Pistia stratiotes as forage crops and as fish feed.
Keywords: Pistia stratiotes, crude protein, crude fat, total nitrogen, fish feed
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P50. Mangabeira, Pedro

Morphology, ultrastructure and mineral uptake is affected by copper toxicity in young plants of Inga subnuda subs. luschnathiana (Benth.) T.D. Penn.

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Toxic effects of copper (Cu) were analyzed in young plants of Inga subnuda subs. Luschnathiana, a species that is highly tolerant to flooding and found in Brazil in wetlands contaminated with Cu. Plants were cultivated in fully nutritive solution, containing different concentrations of Cu (from 0.08 µmol to 0.47 mmol L-1). Symptoms of Cu toxicity were observed in both leaves and roots of plants cultivated from 0.16 mmol Cu L-1.. In the leaves, Cu clearly induced alterations in the thickness of the epidermis, mesophyll, palisade parenchyma and intercellular space of the lacunose parenchyma. Also, this metal induced disorganization in thylakoid membranes, internal and external membrane rupture in chloroplasts, mitochondrial alterations and electrodense material deposition in vacuoles of the parenchyma and cell walls. The starch grains disappeared, however, an increase of plastoglobule numbers was observed according to Cu toxicity. In the roots, destruction of the epidermis, reduction of the intercellular space and modifications in the format of initial cells of the external cortex were evident. Wall cells and endoderm had been broken, invaginations of tonoplast and vacuole retractions were found and, again, electrodense material was observed in these sites. Mineral nutrient analysis revealed higher Cu accumulation in the roots and greater macro and micronutrients accumulation into shoots. Thus, root morphological and ultrastructural changes induced differential nutrients uptake and their translocations from root toward shoots, and this was related to membrane and endoderm ruptures caused by Cu toxicity.

Keywords Cu accumulation; Heavy metal; Cu localization; Ultrastructural changes; Copper toxicity.

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P51. Mench, Michel

Miscanthus giganteus as a Candidate for Phytomanaging Cu-Contaminated Soils

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Miscanthus giganteus was planted on five field plots with Cu-contaminated soils at a former wood preservation site for assessing its Cu-tolerance and suitability to both produce a high biomass with financial opportunities and provide ecosystem services. Four plots display Cu-contaminated soils (i.e. plots #10, 20, 30, and 31 had 306, 163, 1170, and 1016 mg Cu kg-1) and one plot soil Cu and PAH contamination (P7: 467 mg Cu kg-1). Soils were amended with compost and dolomitic limestone either 4 years or 1 month (P7) prior plantation, except in the untreated plot #31 (Unt). Rhizome density was 50 000/ha. Maximum shoot height and biomass of 1-yr, 2yr, and 3-yr-old plants were recorded. Shoot ionome of plants was determined for years 1 and 2. Six out of 10 plants survived in the Unt plot #31 and displayed high shoot Cu concentration (507 ± 145 mg kg-1). All plants developed in amended plots. Shoot biomass and height were higher and shoot Cu concentration lower (down to 17 mg kg-1) in amended plots than in the Unt plot, highlighting the influence of organic matter, soil pH and Ca/Mg nutrition. Despite soil N fertilization, the P7 plants showed foliar N deficiency symptoms. Suitability of M. giganteus and soil amendment to phytomanage these soils will be long-term monitored.

Keywords: Biomass, Ecological restoration, Ecosystem services, Metal, Phytomanagement.

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P52. Menefee, Dorothy

The Effects of Temperature, Moisture, and Management On Soil Microbial Properties in Two Different Soils

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Climate change is one of the most pressing current issues for agricultural production. There is a greater need for understanding how soil carbon cycling impacts global greenhouse gas balances. In order to understand this, it is crucial to understand the processes which store and release soil carbon. In Mollisols, this process is largely mediated by soil macroaggregates which are generally correlated with soil microbial population – particularly fungi. In Oxisols, this process is more related to the stability of organo-mineral complexes formed from metal oxides (particularly Al and Fe). As part of a collaborative, on-going, incubation study, this project aims to explore the various biochemical, and physical factors that affect soil carbon balance. This portion of the project aims to look at the biological controls of these soil C processes. Incubated soils are subjected to four treatments: soil type, temperature regime, moisture regime, and aggregation. The point of these treatments is look more in depth at how climate and management affect carbon storage potential and mechanisms. This part of the study is focusing on changes to microbial population and community structure which is determined with Chloroform-Fumigation-Incubation Microbial biomass and Phospholipid and Fatty Acid analysis (PLFA). Of particular interest effects on the ratio of bacteria to fungi and the effects the ratio of gram positive to gram negative bacteria. The desired outcome of this study is to improve our understanding of soil carbon dynamics both to improve understanding of climate change and to be able to make land-management recommendations.

Key words: soil, soil carbon, climate change, microbial ecology, soil biochemistry

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P53. Mganga, Nyatwere

The Density of Carbon in Miombo Wooodlands Subjected to Different Fire Frequency

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African miombo woodlands are concentrated in the Sub-Saharan region. The United Nations Framework Convention on Climate Change (UNFCCC) under the Kyoto Protocol recognizes the role of carbon sequestration in forests and woodlands. Due to large area coverage and inaccessibility, African savanna fires are normally left unattended hence resulting in outbreaks of uncontrolled and destructive fires commonly called wildfires. It has been reported that wildfires have both negative and positive influence on carbon sequestration in forests and woodlands. The present study was conducted in three forests namely Kitwe, Mgaraganza and Ilunde in western Tanzania. Tree carbon density was estimated using biomass allometric model so far developed for miombo woodlands and the level of significance between the differences of carbon density was determined using ANOVA. Fire frequency of the three forests was interptreted from MODIS (Moderate Resolution Imaging Spectroradiometer) satellite imagery from the year 2001 to 2012. Tree carbon stock was significantly different among the studied miombo woodlands ($P < 0.05$). Furthermore, it was revealed that tree carbon stock was not significantly different between Mgaraganza and Ilunde forests ($P > 0.05$). In Ilunde forest, the average number of wildfires per annum was 35, while in Mgaraganza and Kitwe forests were 0.4 and 0.08, respectively. The effects of wildfires are variable and contradictory depending on the nature of the ecosystems and the existing circumstances. Frequent wildfires and spontaneous suppression resulted in different carbon density. Since fire is crucial in miombo woodlands, then prescribed burning could be prioritized to sustain sinks of carbon.

Keywords: Carbon density, fire frequency, miombo, tree, wildfires

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P54. Mirza, Nosheen

Antimony (Sb) – Pollution and Removal Techniques – Critical Assessment of Technologies

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Antimony (Sb) being toxic, persistent and carcinogenic is a matter of increased environmental concern. Globalization and industrialization are adding to its contamination at a very rapid rate. It is well reported that chemically and in terms of toxicity antimony (Sb) and arsenic (As) are biochemical analogs. Lots of work for As removal is done, but Sb removal is barely touch. Sb is a serious threat for the survival and existence of life, its removal is important. Thus, keeping in view the biochemical analogism of Sb and As, applied As removal techniques are reviewed, with the idea of identifying, the possible Sb removal techniques, with the particular focus on biological process - phytoremediation. For the purpose more than 250 published articles have been reviewed. Advantages and limitations of almost all the techniques are also discussed. It is evaluated, that although the most frequent and applied As removal techniques from soil and wastewater are through adsorbents, membrane separation and soil flushing. But for future, the most promising method to treat complexity of Sb will be the biological treatment -phytoremediation. It is important to know that economical and promising results depend upon the technology selection and its suitability with the local conditions.

Key words: Antimony pollution, Removal techniques, Phytoremediation, Soil, Water treatment.

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P55. Nabukalu, Pheonah

Perennial Phytotechnologies: Associations between Traits of Perenniality and Seed Production

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Once developed perennial sorghum will offer substantial economic and ecological benefits of conserving fuel, water and soil. Sorghum gains its perenniality by being able to over-winter as rhizomes, and produce new regrowth the following spring- a trait derived from its weedy relative, Sorghum halepense (Johnsongrass). We have introduced traits of perenniality into a domesticated S. bicolor background in order to understand its effects on seed production. To develop hybrid perennial sorghum, crosses and backcrosses were made between Sorghum halepense and an elite sorghum inbred line BTx623. In 2013 and 2014, 292 BC1F2 families and their parental accessions were grown in field, in a randomized complete block design with two replicates. One goal of the study was to determine whether deleterious associations exist between degree of perenniality and productivity traits. Such associations should they exist, would hinder breeding progress. Of the 292 BC1F2 families evaluated, 30 % contained plants that expressed rhizome growth in fall. Rhizomatous and non-rhizomatous families differed significantly ($p < 0.05$) for several seed production traits, with the rhizomatous lines tending to be more similar to S. halepense than to S. bicolor. Statistically significant correlations between rhizomatousness and other traits were very weak: number of heads per plant ($r = 0.1243$), number of mature panicles at harvest ($r = 0.1655$), panicle compactness ($r = ¯0.0885$), days to 50 % flowering ($r = ¯0.1956$), seed weight of the main panicle ($r = ¯ 0.0795$), and 1000-seed weight ($r = ¯0.0831$). We conclude that selection for increased perenniality is unlikely to have deleterious indirect effects on domestication traits or grain yield.

Keywords: Sorghum, perennial, weedy, rhizome growth, seed production

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P57. Nasrabadi, Mohsen

Comparative Study of Adsorption Characteristics of Cadmium by Natural Bed Sediment and Zeolite

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Until now many absorbents have been suggested to remove toxic metals from river water. In this study, the adsorption characteristics of cadmium by natural bed sediments (Karaj River, Iran) and zeolite have been experimentally investigated and compared. The effect of various operating variables, such as, initial concentration of cadmium and sediment/zeolite dose has been studied in a circular flume (with a width of 0.2 m) to get enhanced simulations for natural conditions in a river. The experiment conditions were adjusted similar to a natural river (pH=7-8, EC=700-800 µS/cm, and T=25°C). The optimum equilibration time was found to be 5 hr for both materials, which was independent of initial cadmium concentration. The results showed that adsorption of cadmium increased with an increase in sediment and zeolite concentrations. The adsorption value increase by decreasing initial concentration of cadmium. The results of this study showed that the adsorption of cadmium by natural bed sediments was more than zeolite up to about 30 percent. To interpret this difference, these materials have been analyzed by the XRD and XRF techniques. Also the adsorption data were analyzed using the Langmuir and Freundlich adsorption models to determine the mechanistic parameters related to the adsorption process.

Keywords: Adsorption, Bed sediments, Zeolite, Cadmium

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P58. Naughton, Gary

Beneficial Effects of Trees at the Riley County Landfill

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In 1985 the Kansas Department of Health and Environment found volatile organic compounds (VOCs) in private well water near the Riley County landfill. The landfill has been closed and a cap has been installed. Trees were planted down gradient of the landfill to increase evapotranspiration and to reduce the flow and concentration of contaminants beyond the property owned by Riley County. The first trees were planted in 1998, and additional trees were planted each year through 2005 as a service project of Tau Beta Pi. From 1998 to the present, the concentrations of the volatile compounds in the groundwater down gradient from the landfill have decreased. In the most recent report, that was prepared in 2014, chlorobenzene is the only VOC detected and the concentrations are below 1 microgram per liter. The groundwater flows under the landfill and into the area that has been planted with trees. The mean residence time of water from the landfill to the far edge of the tree plantation is more than one year. The trees remove a significant amount of water through evapotranspiration, and the cost of doing this has been much less using trees compared to installing wells and pumps.

Keywords: phytoremediation, landfill, evapotranspiration, groundwater, volatile organic compounds

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P59. Navarro-Aviñó, Juan

Decontamination of fossil fuels and other organic compounds by plants

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In the search for a wider range of solutions to the most important global pollution, tools have been studied, and investigated with positive results against heavy metal contamination compared to other previously tested contaminants such as oil, gasoline, or detergents . These tools are genetically modified plants have the ability to show hyperaccumulation by having but plant biomass 100 times greater. Were also obtained in this case, positive results, pointing to these plants as a possible solution, not only against inorganic compounds as heavy metals often form, but against a class of contamination that is present recurrently in today activity, across the globe, such as that produced by fossil fuel spillage, often caused recently in maritime navigation.

Keywords: petroleum, oil, detergent, heavy metals, salinity.

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P60. Oloumi, Hakimeh

Effect of Carbon Nano-Tube on Lead and Cadmium Absorbency by Plants

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The effect of carbon nano-tube application for higher lead and cadmium absorption from the surrounding growth medium of some plant species has been studied. 0, 10 or 50 mgL-1 multi-walled carbon nano-tube (MWCNT) were added to sterile agar medium of four important crops seeds (sorghum, cannabis, sunflower and canola) containing either 0, 10 µM Pb(NO3)2 or CdCl2. The Petri-dishes incubated at room temperature (28±2ºC) under 40 W tubes light for one week. The atomic absorption spectrometry of seedlings indicates that MWCNTs have a positive effect on the cadmium and lead accumulation in canola and cannabis seedlings. MWCNTs treatment also caused higher absorption of cadmium but not Pb in sunflower and sorghum. Based on the shoot and root length and weigh, seedlings growth was higher in MWCNT treated samples under Pb and Cd stress in all species under study. A lower lipid peroxidation (MDA content) in carbon nano-tube treated samples shows that it can alleviate the toxic effect of cadmium and lead despite higher metal absorption. This study features the potential of carbon nanotubes as a candidate for heavy metals chelator in phytoextraction techniques.

Keywords: carbon nan-tube, heavy metals absorption, plants

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P60A. Otte, Marinus

ZnO-nanoparticles are sensed by plants, but do not affect growth or uptake of Zn

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The aim of this experiment was to study the uptake and effects of ZnO-nanoparticles in spinach (Spinacea oleracea). In contrast to most studies, which are often based on short-term experiments (up to two weeks), our plants were grown to maturity, and were exposed to ZnO-nanoparticles and bulk-ZnO (mostly larger than the size of nanoparticles) at 0, 50 and 500 µM. The plants in the different treatments showed no differences in biomass production among the treatments, and no differences in Zn uptake between the bulk and nanoparticle forms. However, when we used RNA-sequencing to evaluate global gene expression we did find differences between treatments in genomic expression. Gene set enrichment analysis identified functional categories enriched in nanoparticle treated roots compared to the bulk-ZnO control. Up-regulation of transcript assemblies (TAs) associated with biotic stress responses, jasmonate synthesis, protein degradation, redox, sulfate assimilation, and cell wall precursor synthesis suggested that ZnO nanoparticle exposure elicited responses similar to necrotrophic pathogen responses. This showed that Zn oxide nanoparticles had an effect upon the plants even when there was no significant effect on plant growth or on Zn uptake and translocation.

Keywords: nanoparticles, spinach, Spinacea oleracea, genome, zinc

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P61. Pagano, Luca

Nanomaterials and crop plants: health and environmental safety related to molecular effects of ENMs exposure

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The aim of this work is to identify sensitive molecular biomarkers in agricultural crops that indicate exposure to engineered nanomaterials (ENM). Appropriate biomarkers can be used as both descriptor and predictors of exposure and effects. In vivo functional toxicology is already utilized for the identification of genes involved in tolerance and sensitivity to nanomaterials in model plant systems (Marmiroli et al., 2014). Transcriptomic and proteomic approaches, following identification of orthologs genes (involved in metabolic functions, detoxification and stress response, transports, protein synthesis and DNA repair) across different species, can significantly augment conventional morphological and physiological data on plant response. Species amenable to such approaches include crop plants such as maize, rice, tomato or zucchini, several of which have already been investigated with regard to food safety and engineered nanomaterials (De La Torre-Roche et al., 2013; Hawthorne et al. 2014). About 70 candidate/target genes identified in this way will be validated through transcriptomic/proteomic analyses. Comparative analyses of the identified target genes will lead to the selection of a panel of genes which are candidates as biomarkers of early and late effects of nanomaterial exposure. A system biology approach will allow the target genes to be linked in a complex network, representing molecular pathways, cellular components and biological processes involved in ENMs response. Some of the target genes are expected to represent biomarkers of susceptibility, which affect (modulate) the response in different genotypes or cultivars.
Keywords: Nanomaterials, Crop plants, Ecotoxicology, Food safety.
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P62. Paz-Alberto, Annie Melinda

Assessing Diversity and Phytoremediation Potential of Seagrass in Tropical Region, Philippines

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Seagrasses support and provide habitats for many coastal organisms in tropical region. Seagrasses are specialized marine flowering plants that have adapted to the nearshore environment with heterogeneous landscape structures of shallow-water estuarine/marine ecosystems. This unique feature of seagrass has rendered it to have high phytoremediation potential. Phytoremediation is a cost-effective plant-based approach and environmentally friendly solution for heavy-metal contaminated sites. The main objectives of the study were to determine the current status and diversity of seagrass ecosystem and to assess the phytoremediation potential of seagrass for lead and chromium in tropical region. Diversity of seagrass species in the study area was relatively low and only a few number of individuals per species were present due to environmental degradation caused by natural and human activities. Using the Shannon Diversity Index, the seagrass beds at Candelaria site had a diversity mean value of 1.6 while the Masinloc site had 1.1, which indicate that both sites have very low diversity of seagrass. Lead and chromium were not present in water while chromium was present in the sediment of the seagrass ecosystem in Candelaria and Masinloc, Zambales. Cymodocea rotundata was found to be a good phytoremediator for lead due to high amount of lead absorbed in both seagrass ecosystems.

Keywords: diversity, phytoremediation, seagrass, chromium, lead

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P63. Popek, Robert

Amount of PM on leaves of Quercus robur L. depending on crown site, height and distance from the source of pollution.

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One of the most dangerous pollutants created by traffic is particular matter – PM. It can be suspended in the air even for weeks as aerosols, and when inhaled it can have carcinogenic, allergic and mutagenic effects. If pollutants have been emitted to the atmosphere, the only possible method to clean the air is via environmental biotechnology - phytoremediation. It involves growing plants on the surfaces of which PM are deposited. he subject of our research was English oak (Quercus robur L.) leaves remaining on tree during the winter season. We attempted to (i) evaluate the effect of distance from the source of pollutant emission on PM accumulation on the leaves of trees growing at 3 spots (20m, 50m and 100m from the edge of the highway). We also attempted at (ii) evaluating the amount of PM on the leaves from 3 heights (1m, 2m and 3m) and 4 sides of oak crown growing near by the highway edge. In both experiments amount of PM of two categories and three size fraction were measured.
There were significant differences between distances in PM accumulation on oak leaves. The highest amount was measured on trees near the road. The most effective in PM accumulation were leaves growing on all heights of crown facing the highway. There were also differences between PM types and size fractions.
Acknowledgements: The study was financed with funds of Polish National Science Center awarded under the internship after obtaining doctoral degree based on decision number DEC-2014/12/S/NZ9/00716.
Keywords: air phytoremediation, English oak, leaves, trees, particulate matter
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P64. Rajawat, D.S.

Voltammetric determination of cadmium using Citrus Limon Peel Modified Carbon Paste Electrode

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A new modified carbon paste electrode was developed for the voltammetric determination of cadmium which shows enhanced activity toward metal determination in aqueous samples. Carbon Paste Electrode was prepared by mixing Graphite Powder, Nujol and Citrus Limon Peel i a varyin ratio. Prepared Carbon Paste Electrode was characterized using Cyclic Voltammetry, Electrochemical impedance study and Atomic Force Microscopy. Stripping voltammetry was used for metal determination. Different conditions for the determination of cadmium were examined to get the optimized performance of this new metal sensor. Different experimental conditions optimized are 12.5 % modifier, Acetate buffer as supporting electrolyte with pH 6, HCl as stripping solvent and 15 min accumulation time. The effect of surface active macro molecules was also studied. Enhancement in metal determination has been observed with the modified electrode for Pb (II) and Cd (II) as compared to the bare CPE. The limit of detection values observed are 64.4 ppb for Cd (II).

P65. Rogova, Tatiana

Reforestation degraded agricultural lands at landscapes of forest-steppe Eurasian biome

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Sustainability of agricultural landscapes and economic efficiency is reduced due to the low productivity of degraded arable lands. Strong plowed land, low total area of forests (10-17%), and a low percentage of protected forests of arable landscapes (less than 2%) are the cause of erosion and land degradation. Under these conditions, the most important is improving the quality of the natural environment and biodiversity. Improvement of the environment and forest sustainability in the deforested territories of the Middle Volga region of Russia demands increase forest cover of 1.5 times, expanding the network of protected areas to 3%. Assessment of the ecological value of forests in sustaining landscapes was held on the profile crossing the Volga valley in the direction from north to south. At the 13 polygons (575 ha total area) detailed investigations had been done. The studies found that abandoned farmland in the process of successful natural regeneration. In general, the nature of reforestation of all investigated sites has common features of the transition from stage sparse cover of ruderal and grass species to meadows and continue to pioneer species forest stands of pine and birch trees, sometimes with the participation of indigenous species of linden, oak and spruce. Reforestation technology provides the formation of mosaic structure including spatial community elements of different species composition, reflecting the stage of the recovery process. Forest ecorestoration successfully solves the problem of the provision of ecosystem services, and increasing the productivity of agricultural land.
Keywords: reforestation, forest-steppe landscapes, pioneer trees

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P66. Sabir, Muhammad

Bioassessment of heavy metal contamination in soils, water, and plants in suburbs of Faisalabad and mapping through GIS

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Farmers of many developing countries including Pakistan use raw city effluents of high nutrition value and organic matter to irrigate their farmlands especially at critical growth stages of crops when canal water remains unavailable matter. This is very common practice in the suburb of Faisalabad where this raw effluents also carrying heavy metals which not only affect soil and plant health but also a continuous threat for food chain. The study was conducted to quantify the concentration of metals (Pb, Ni, Cu, Fe, Zn and Mn) in soils, waters and plants in the suburb of Faisalabad, Pakistan. Samples of soils, available plants and water were collected following agrid size of 4 × 4 km along roadside in the urban, peri-urban, and rural areas. The concentrations of lead (Pb), nickel (Ni), copper (Cu), iron (Fe), zinc (Zn) and manganese (Mn) in plants were ranged from 1.00 to 13.99, 0.13 to 4.38, 4.34 to 46.99, 407.31 to 1133.38, 7.98 to 55.85 and 37.34 to 149.51 mg kg-1, respectively. The concentrations of these metals in soils and water were observed under permissible limits but their continuous and heavy use is getting alarming as the metal concentration in plants were above permissible limit in most of the sites. The chemical properties of soils and waters were diverse but positively correlated with the metal concentrations in plants with varying degrees. Geographic information system based maps were made using software Arc map version 10.1 showing the heavy metal contaminated hit areas.

Key words: (Bioassessment, Heavy metals, sewage water, plants, GIS mapping)

P67. Sampanpanish, Pantawat

Effect of NTA and EDTA on Arsenic Uptake from Contaminated Soil by Mimosa pudica

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The purposes of this study were to determine arsenic accumulation in the root, stem and leaves of Mimosa pudica L. and compare the efficiency of two chelating agents, in enhancing arsenic uptake by the plant. This study also investigated the distribution of arsenic in the plant. The results showed that arsenic accumulation in root was significantly higher than in stem and leaves ($P \leq 0.05$). The maximum arsenic accumulated in roots, stem and leaves were 29.71 and 6.32 mg arsenic/kg plant, after 120 days, respectively. The average arsenic accumulation in all parts of the plant over four months was in the range of 2.71 - 36.03 mg arsenic /kg plant and set ethylenediaminetetraacetic acid 100 mg/kg soil showed the highest arsenic accumulation in Mimosa pudica L. Overall, with the same harvesting times and application doses of chelating agents, ethylenediaminetetraacetic acid has a greater efficiency for enhancing arsenic uptake in this plant than nitrilotriacetic acid. Moreover, the synchrotron μ-X-ray fluorescence spectroscopy (Beamline 6b) analysis provided an unexpected result on the distribution of arsenic in the plant caused by the limitation of the radiation beam line. However, this research did not study the chemical reactions between arsenic and the chelating agents. Therefore, for future studies it is recommended that more detail at molecular level be investigated and more study be done on the influence between the applications of fertilizers and without fertilizers which might help us to clarify the factors that stimulate the movement of arsenic from the soil up to the plants.

Keywords: Nitrilotriacetic acid, Ethylenediaminetetraacetic acid, Arsenic, Mimosa pudica, Soil

P68. Sánchez-López, Ariadna

Visualization of mCherry-labeled seed endophytic Methylobacterium in Crotalaria pumila seedlings

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Methylobacterium sp. is an endophytic bacteria isolated from consecutive generations of Crotalaria pumila Ort. seeds, a plant species able to grow on mine residues containing metals. This strain produces indole-3-acetic acid, solubilizes phosphate, has 1-aminocyclopropane-1-carboxylate deaminase activity and it is tolerant to Zn, Cd and Pb, all desirable characteristics of a plant-associated bacteria. To gain a better understanding of the plant colonization abilities of this strain, Methylobacterium sp. was transformed with a stable plasmid harboring the mCherry construct (pMP7604). Crotalaria pumila seeds were inoculated with this mCherry-labeled fluorescent strain using a gnotobiotic system, with or without Cd and Zn in the medium. Plant colonization was studied using confocal laser scanning microscopy. Methylobacterium pMP7604-tagged cells colonized the main root and root hair surfaces extensively; and they were detected intracellularly in the root cortex. It was shown that in the presence of metals labeled Methylobacterium colonized the xylem vessels in root and shoots of Crotalaria. The transformed strain was re-isolated from surface-sterilized roots and shoots of inoculated plants, confirming its endophytic colonization abilities and survival in planta. Our results confirm that Methylobacterium sp. is a true endophyte which can play an important role in plant growth-promotion, and fitness, in metal contaminated conditions. Additionally, our observations support the hypothesis that seed endophytes can enter root cells, move through the xylem and reach different organs (e.g. shoot and seeds) and thus they can be transferred to successive plant generations. These results hold promise for novel applications of endophyte-stimulated phytoremediation of metal-contaminated soils.

Keywords: plant growth-promoting endophyte, mCherry protein colonization, xylem
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P69. Sanni, David M.

BIODEGRADATION OF PHENOL BY WATER HYACINTH EXTRACT AND PHYSICOCHEMICAL PROPERTY OF THE POLYPHENOL OXIDASE

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Polyphenol oxidase activity was measured in different tissues of Water Hyacinth (Eichhornia crassipes) of the plant. The results of water hyacinth extract (leaf, stalk and root) with model phenol (pyrocathecol, 3, 4- dihydrphenylalanine and bisphenol) showed that the extract biodegrade these phenol. Three isoforms of water hyacinth polyphenoloxidase was observed in the native gel electrophoretic pattern; two similar bands in both leaf and root plus one unique band in the root extract. The optimum temperature and pH were found to be 450C and 7.5 respectively. The enzyme was stable for one hour at 300C, 400C and 450C. The root extract showed a higher activity for diphenol substrate while the leaf shows a higher activity for monophenol, indicating variations in the distribution of monophenol and diphenol activity in water hyacinth tissues. The Km and Vmax value for leaf are 1.90mM, 2.8mM and 29.76unit/min, 25.91unit/min while that of root extract are 6.58mM, 2.41mM and 98.04unit/min, 103.09unit/min using 3.4-dihydrophenylalanine and pyrocathecol.
Aqueous extract of Water Hyacinth can be used in removal of phenolic compound in water body in combination with treated Hyacinth straw especially in an effluent system with continuous aeration.

Keywords: Water Hyacinth, optimum, extract, Phenol, activity

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P70. Sanyaolu, Adeniyi

THE EFFICIENCY OF FERMENTED AND UNFERMENTED SEED EXOCARP OF PENTACLETHRA MACROPHYLLA (BENTH) AS AN ORGANIC SOIL AMENDMENT

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Soil amendment includes all inorganic and organic substances mixed into the soil for achieving a better soil constitution regarding plant productivity. This study investigated the comparative efficiency of Aspergillus niger fermented (Treatment A) and unfermented (Treatment B) exocarp of Pentaclethra macrophylla seeds worked into the top soil. Treatment C was the Control soil containing neither the fermented nor the unfermented exocarp. The three Treatments were delineated on the Field as a 3 x 3 Randomized Complete Block Design (RCBD). The experimental field was left undisturbed for seven days after the addition of the Treatments. Thereafter, the soils of each Treatment were taken to the laboratory for a determination of their physico-chemical properties. The results of this experiment show that the application of Treatments A and B significantly improved ($p \leq 0.05$) the mean values of most of the physico-chemical parameters compared to the Control soil. However, the mean value of available phosphorus in the soil was not significantly ($p \leq 0.05$) affected by the application of Treatments A and B. For the exchangeable bases the results show that the mean value for Treatments A and B were significantly higher ($p \leq 0.05$) than those of the Control Treatment. The addition of this agricultural waste to an arable soil has shown some promise as a probable alternative to the expensive and ecologically toxic synthetic fertilizer.
Keywords: soil amendement , Agricultural waste, seed exocarp, Pentaclethra macrophylla seed, Aspergillus niger.

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P71. Sardar, Andleeb Anwar

International Phytotechnologies Conference 2015 Sample Abstract

Sardar, Andleeb (Presenting Author)

In vitro antioxidant potential and free radical scavenging activity of various extracts of pollen of Nelumbo nucifera Gaertn.

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Antioxidant potential of the pollen of Nelumbo nucifera Gaertn using Ferric Reducing Power, Metal Chelating Activity and Trolox Equivalent Antioxidant Capacity (TEAC) assays has been carried out in the current research work. The antioxidant components were initially extracted from the pollen in methanol and were further fractionated in solvents of different polarity such as n-Hexane, Chloroform, Ethyl Acetate and Water. Methanol extract which was found to have high reducing power and total phenolic contents has considerable prospective to utilize as a natural antioxidant and be capable to link with the total phenolic contents of plant. Phenolic compounds obtained from raw materials of plants are strong lipid peroxidation inhibitors and efficient free radical scavengers. A variety of herbal medicines have got tremendous repute for the treatment of several diseases. Therefore, now a days various folk medicines in single and or in combination are used to treat diverse types of inflammatory and arthritic ailments. Medicines derived from raw materials of plants are also getting popularity due to the belief that "Green medicine" is secure with fewer side effects than the synthetic drugs.

Key Words: Green medicine, Antioxidants, Phenolic Compounds, Nelumbo

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P72. Shores, Amanda

Salted Wounds: Candidate Phytoremediators for Produced-Water Spills

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The vast quantity of brine produced by oil-and-gas extraction techniques presents an urgent challenge for sustainability. This "produced water" contains toxic organics such as BTEX compounds and naphthalene, a PAH. Produced-water spills are common; in Colorado, there is about one spill per day. As an alternative to the excavation of tainted soil, plants could be employed to degrade, sequester, and/or volatilize organics in soil, providing economical in situ remediation. However, the salt in a produced-water spill might limit plant biomass, root length, and germination rate, traits important for effective plant-based remediation. Therefore, we selected seven grass species already present in Weld County, CO, and tested their tolerance of salt levels typical of a produced-water spill in a greenhouse setting. After four weeks of periodic watering, root length, biomass, and germination rate were assessed. Blue gramma showed significant linear decreases in root length, root mass, and shoot mass relative to controls, indicating this species to be salt-sensitive. Buffalo grass, alkali sacaton, and foxtail barley showed no significant differences between treatments in any measured parameter, indicating very high salt tolerance. Perennial ryegrass, foxtail barley, and buffalograss grew most vigorously overall, across all treatments, indicating acceptable salt tolerance and possible high suitability for spill phytoremediation. These three species will continue on to a further greenhouse study evaluating their ability to remediate BTEX compounds and naphthalene in the presence of high salt concentrations, with the goal of identifying Colorado native species optimal for produced-water spill site remediation.

Keywords: grasslands, oil-and-gas byproducts, produced-water spills, BTEX, salinity tolerance

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P72A. Sillen, Wouter

The rhizosphere microbial community as mediator in the response of maize to silver nanoparticles

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Nanotechnology has offered the opportunity to make use in the most efficient way of the well-known anti-microbial properties of silver. Despite this great benefit for a myriad of industries, silver nanoparticles are also a significant reason for concern as they exert their toxicity to non-target microbes and plants. Agricultural crops like maize (Zea mays sp.) in particular are likely subjects of silver nanoparticle exposure, as these particles may enter the agro-ecosystem during manufacturing, from use of nano-enabled agrichemical products, and from the application of nanoparticle-containing biosolids. Maize plants growing in hydroponics respond to silver nanoparticle exposure by producing less biomass, while exposure to realistic concentrations in natural soil has been found to increase maize biomass. Because of silver's antimicrobial properties, microbial communities associated with maize are expected to be important mediators in this outcome, although very few studies have been conducted in combined plant-microbial systems.

Our results confirm the existence of a strong link between the responses of maize and the microbial communities in its rhizosphere to silver nanoparticles. The specific conditions that shape the rhizosphere also alter the effects of silver nanoparticles on microbial communities, compared to the bulk soil. The link between plant and rhizobiome responses highlights the role of rhizosphere microorganisms in the welfare of their host plant and its response to contaminants. As such, the impact of exposure on plant-associated microbial communities presents itself as an important factor that should be included in fate and effects assessment of widely used materials such as silver nanoparticles.

Keywords: soil, rhizosphere, silver nanoparticles, maize, microorganisms

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P73. Starsman, Jessica

Assessing the use of Salix alaxensis for the Rhizoremediation of Diesel-Contaminated Soil

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Throughout Alaska there are many contaminated sites that cannot be reached by roads that require remediation. In the case of the remote community of Kaltag, Alaska tank farms were established in the early 1960's and since that time there have been multiple diesel spills. Rhizoremediation using native plants is a potentially cost-effective method for remediating soils contaminated with organic contaminants, but has not yet been extensively tested in Alaska. Native plants have the added benefit of being adapted to local conditions. The willow Salix alaxensis is native to Alaska and in previous studies has been shown to promote diesel biodegradation in soil and alter the diversity of active naphthalene degraders. These effects could potentially be related to the release of salicylic acid as a secondary root compound. Due to the presence of weathered diesel, the remote location and the costs of ex-situ remediation, the use of Salix alaxensis for rhizoremediation of the site was studied. Microcosm studies were performed with crushed Salix alaxensis root, mimicking root turnover, as well as salicylic acid and fertilizer on the biodegradation of fresh and weathered diesel in Kaltag soils. With cold weather dominating much of the year, half of the microcosms were incubated at 4ºC as well as 20ºC to simulate summer conditions. Diesel losses were quantified using GC-MS, respiration was monitored using respirometry, and populations of diesel-degraders were quantified using most probable number (MPN) methods. Preliminary results indicate that the soils possess substantial diesel-biodegradation abilities, and analyses of the effects of willows and other treatments are in progress. If found to be effective for biostimulation, the use of Salix alaxensis would be advantageous as cuttings could be taken directly from the local region. Future field-scale tests are planned in Kaltag to determine the effectiveness and costs of phytoremediation using native willows and other plants in relation to land farming methods.

Keywords: rhizoremediation, diesel, cold, willow, rural community, plant secondary compounds, fine root turnover

P74. Stefanovska, Tatyana

POTENTIAL TO EVALUATE THE EFFICACY OF PHYTOTECHNOLOGY WITH MISCANTHUS X GIGANTEUS AT THE ABANDONED MILITARY SITES BY USING SOIL NEMATODES AS BIOINDICATORS

Tatyana Stefanovska* , NULES, Valentina Pidlisnyuk, MBU, Larry Erickson, KSU, Mykola Dolya, NULES, Edwin Lewis, UCD, Yulia Vystavna, NUUE

Within invertebrates, nematodes occupy key position in soil food webs. This long term model study was initiated in 2013 using real soil taken from abandoned military sites in Kamenetz-Podilsky, Ukraine with overall objectives: access the ability of Miscanthus X giganteus to grow on contaminated soil and to stabilize it; explore the ability of this energy crop to support soil nematode diversity and to provide economically important services that are produced by healthy soil.
Results indicate that soil nematodes isolated from abandoned military sites contaminated by Cr, Mn, Zn and Pb can be assigned to five trophic groups belonging to 10 Genera and 11 Families. Nematodes in this soil were characterized by: increasing of total nematode biomass; high total nematode density, low taxonomic richness and species diversity; a shift of community structure; dominance of certain nematode taxa in trophic groups compositions; maturity index decrease. Among trophic groups, plant parasitic root nematodes dominated followed by Bacteriovorus. The nematode community analysis provides the insight on pathways for decomposition in the soil food webs, status of nutritional balance, soil acidity and the impact of soil pollutants. Soil nematode can be used for biomonitoring the efficacy of remediation efforts within the landscape context.

Keywords; abandoned military sites; heavy metals; phytotechnologies; Miscanthus x gigantheus; soil nematodes
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P75. Struckhoff, Garrett

Algal Conversion of Brewery Waste to Biofuel

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Brewery waste is a potent source of nutrients and biochemical oxygen demand (BOD). Roughly 5 billion gallons of brewery waste were created in 2013, in the USA alone. Standard procedure at many craft breweries is to dispose of the waste via domestic sewage collection. However, brewery waste consists almost entirely of plant products with a small amount of yeast as well. Those residual plant materials may be the perfect building blocks for algal growth and biofuel production. The objective of this project was to identify means of reducing the nutrient and BOD loading at the wastewater treatment plant and to create value-added products from brewery waste.

The algea, chlorella vulgaris, was used to reduce nutrient concentrations in brewery waste. Nitrogen and phosphorus species were examined during the course of experiments conducted under natural and artificial lighting. Algal growth was assessed via optical density spectroscopy.

Several interesting results were obtained. Nutrient concentrations were reduced due to algal uptake, as expected. However, an unexpected result is that higher concentrations of brewery waste seemed to decrease algal growth rates. Hops, a traditional flavoring agent in beer, are known to exhibit anti-microbial properties, and may be the causative agent of this observed growth inhibition. Inhibition studies are being performed currently and by the time of the conference will have elucidated the impact of hop acids on algal growth.

Keywords: Brewery waste, algal, biofuel, upcycling

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P76. Sugawara, Kazuki

Evaluation of arsenic behavior in temperate-zone plant, Pteris multifida

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Arsenic (As) contamination in soil and water has been recognized in worldwide. For this As pollution, some phytoextraction and phytostabilization projects have been operated. Frequently, Pteris vittata, a subtropical-zone plant, was used for such kind of project in temperate zone, but the limited cold tolerance was an issue for widely application. Pteris multifida, an As hyperaccumulating plant, was expected having higher cold tolerance than P. vittata. Though, detail of As behavior in P. multifida has not been observed. In the present study, As behavior in P. multifida was investigated as compared to P. vittata to evaluate applicability of phytoremediation in temperate zone. P. multifida accumulated As as AsIII mainly in shoots and rhizome. Additionally, foliar applied As was translocated from As exposed frond to non exposed frond via rhizome. In the field trial, P. mutifida and P. vittata were cultivated from late spring to winter in As containing site, Miyagi prefecture, Japan. P. vittata blighted whereas P. multifida was still verdant in winter. P. multifida accumulated As in rhizome significantly, and total As accumulation amount was approximately same as P. vittata. According to the result of field study, P. multifida was possible to apply in temperate instead of P. vittata for As remediation.

Keywords: arsenic, transport, phytoextraction, Pteris multifida, Pteris vittata

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P77. Tarla, D.N.

Inventory of obsolete pesticide stockpiles in Cameroon

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Pesticides become obsolete and/or unwanted when they can no longer be used for their intended purposes. They become hazardous waste to public health and environment. However, the quantity of these chemicals is not known. The purpose of this work was to investigate the quantity of obsolete pesticide stockpiles in Cameroon. A two-prooked method including a declarative method by outreach campaign using booking forms and direct inventory by systematic visits were conducted from 2009-2011 in Cameroon. A total of 31 015 kits were distributed in the 58 divisions of the country and 543 forms were filled. A total of 353 stores were visited. In both methods, 210047.1 kg and 309521.0 l of obsolete pesticides were inventoried with 4 146 kg of persistent organic pollutants. For empty pesticide containers, 23 926 and 32 431 empty sachets and non sachet containers were registered. The quantities of obsolete pesticides were high and stakeholders are called to remediate the current situation and stop future accumulations.

Key words: obsolete pesticides, inventory, empty pesticide containers, outreach campaign, declarative method

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P77A. Yanitch, A.

Molecular identification and analysis of arsenic stress-responsive genes in willows Salix purpurea "Fish Creek"

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The toxicity of arsenic (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. The objective of this study is to understand how willow, a specie that has interesting abilities for phytoremediation, is able to extract and endure as contaminants. Results from a four weeks hydroponic study with Salix purpurea 'Fish Creek' rooted cuttings 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 their tissues. Differential gene expression analyses (RNA-seq) processed on these tissues led to the identification of 274 differentially expressed genes in stem, 930 in leaves and 545 genes in roots. Annotations from 4 different databases gave functions of all the isoforms associated to genes expressed in response to as contamination. These results help us to develop a better understanding of the mechanism involved in as metabolism in willows from the entry in roots and repercussions on other organs. Ultimately, we'll be able to design markers in order to assist selection for more effective depolluting species.

Keywords: willows, arsenic, RNAseq, gene expression

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P78. Zhang, Weilan

The Effect of Aging on the Bioavailability of Cerium Oxide Nanoparticles to Raphanus sativus L.

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Even though engineered nanoparticles (ENPs) are broadly used in industry, their fate and impact on soil-grown plants are poorly understood. Our previous research demonstrates that the soil properties play a significant role in governing the fractionation of cerium oxide nanoparticles (CeO2 NPs) in soil and their bioavailability to plants. However, the nanoparticles were freshly introduced to the soil. It is well recognized that aging is an important process affecting the fate and impact of environmental pollutants. Thus, the main objectives of this investigation were (1) to evaluate the aging effect on the fractionation of CeO2 NPs in soil and their bioavailability to radish; (2) to determine the aging effect on the nutritional status of radish storage root. The experiment was conducted in a growth chamber with 1000 mg/kg freshly spiked CeO2 NPs or amended soil with the same concentration of CeO2 NPs and aged for seven months. The physicochemical properties of soil were carefully characterized prior to the study. CeO2 NPs fractionation was determined through a sequential extraction method to separate cerium into four fractions: the exchangeable, water/acid soluble metal; the metal bound to Fe-Mn oxides; the metal bound to organic matter; and the metal in the residual fraction. Radish was grown in the above mentioned soils for 28 days. At termination, the cerium concentrations in different radish tissues and the concentrations of several key macro and micronutrients were determined. The results indicate important aging effect that must be considered in evaluating the fate and impact of ENPs.

Keywords: cerium oxide nanoparticles, aging, radish, bioavailability, soil fractionation

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P79. Zhang, Xue

Effects of arbuscular mycorrhizal fungi on CH4 emission from rice paddies

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The diurnal variations of methane (CH4) emission from rice paddies with and without addition of arbuscular mycorrhizal fungi (AMF) were measured at three stages including midseason drainage, reflooding and draining. The experiment was conducted in a rice field in Yixing city, Jiangsu province, China in 2012. The results showed that the diurnal variation pattern in the two treatments both closely tracked soil water content at midseason drainage and draining stage, while correlated very well with the stomatal conductance of rice at reflooding stage. There were no significant differences between treatments in soil water content and stomatal conductance. However, the diurnal CH4 emission flux at the three stage ranged from 4.8-39.3, 0.9-12.4 and 0.2-2.3 mg·m-2·h-1 in the non-inoculated plot, and that in the inoculated plot was 2.1-18.7, 0.9-5.0 and 0.3-1.2 mg·m-2·h-1. The significant differences resulted from carbon to nitrogen ratio (C:N) of the non-inoculated and inoculated soil, which had a negative linear correlation with maximum diurnal CH4 flux. The pearson correlation coefficient is -0.874 ($n=6$, $p<0.05$). Compared with non-inoculated treatment, inoculation with AMF significantly increased C:N of the soil. This was achieved by allocating more C (increasing by 11.6-57.3%) to below ground and translocating more N (increasing by 28.0-41.1%) to above ground at the three stage. Consequently, inoculation with AMF could be a potential method for mitigating CH4 emission from rice paddies.

Keywords: rice paddy, CH4 emission, arbuscular mycorrhizal fungi, carbon to nitrogen ratio
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