ICHMET 2020

20th International Conference on Heavy Metals in the Environment

October 25 (Sun) - 29 (Thu), 2020

FKI Tower & Conrad Seoul, Seoul, Korea

Organized by APRU 고려대학교 KOREA UNIVERSITY KBRC Korea Biochar Research Center 한국환경생물학회 GMRC

Co-organized by BERGISCHE UNIVERSITÄT WUPPERTAL GHENT UNIVERSITY THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Sponsored by sto 서울관광재단 SEOUL TOURISM ORGANIZATION KOREA TOURISM ORGANIZATION 한국관광공사 서울특별시 SEOUL METROPOLITAN GOVERNMENT KOFST Korean Federation of Science & Technology Societies

In Collaboration with scinapse pluto xSync

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Organized by

APRU Sustainable Waste Management
고려대학교 KOREA UNIVERSITY
KBRC Korea Biochar Research Center
한국환경생물학회 Korean Society of Environmental Biology
GMRC

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KOREA TOURISM ORGANIZATION 한국관광공사
서울특별시 SEOUL METROPOLITAN GOVERNMENT
KOFST Korean Federation of Science & Technology Societies

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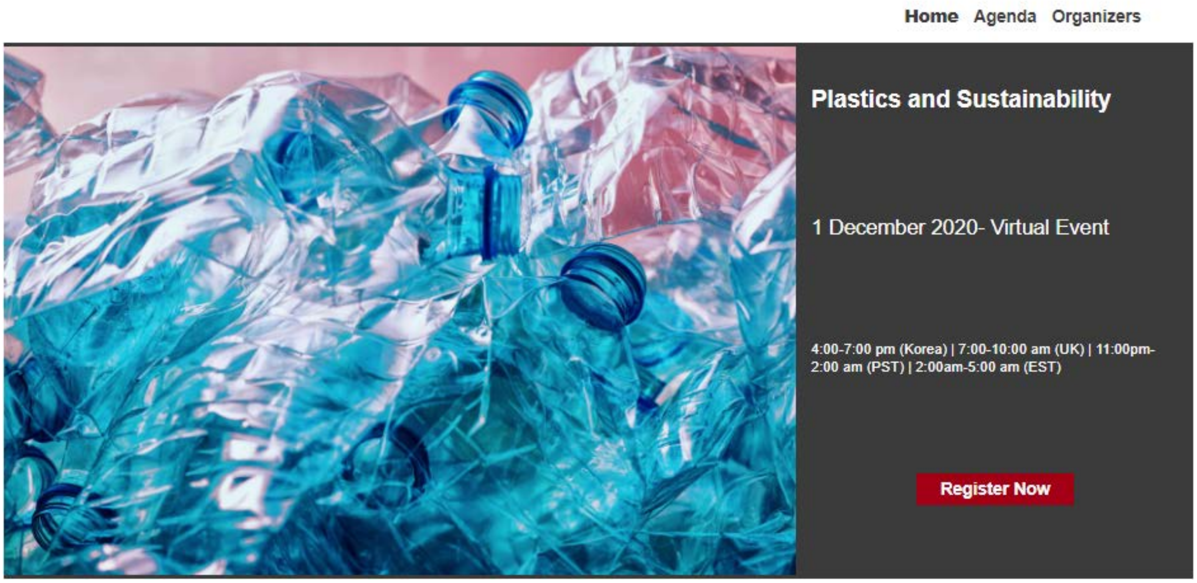
Published on October 25, 2020
Published by Prof. Yong Sik Ok, Korea Biochar Research Center
and APRU Sustainable Waste Management Organizing Committee

Nature Forum

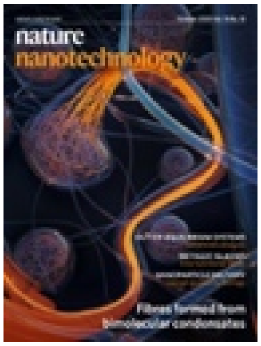


Plastics and Sustainability

1 December 2020- Virtual Event

4:00-7:00 pm (Korea) | 7:00-10:00 am (UK) | 11:00pm-2:00 am (PST) | 2:00am-5:00 am (EST)

Scientific Organizing Committee



Dr. Fabio Pulizzi
Chief Editor
Nature Nanotechnology

Dr. Laura Zinke
Associate Editor
Nature Reviews Earth & Environment

Dr. Woo Kyun Lee, Director
OJeong Resilience Institute
Korea University

Prof. Yong Sik Ok, Director
APRU Sustainable Waste Management Program
Korea University

Dr. Yohwan Son, Director
Asia Resilience Center
Korea University

KOREA UNIVERSITY

APRU Sustainable Waste Management

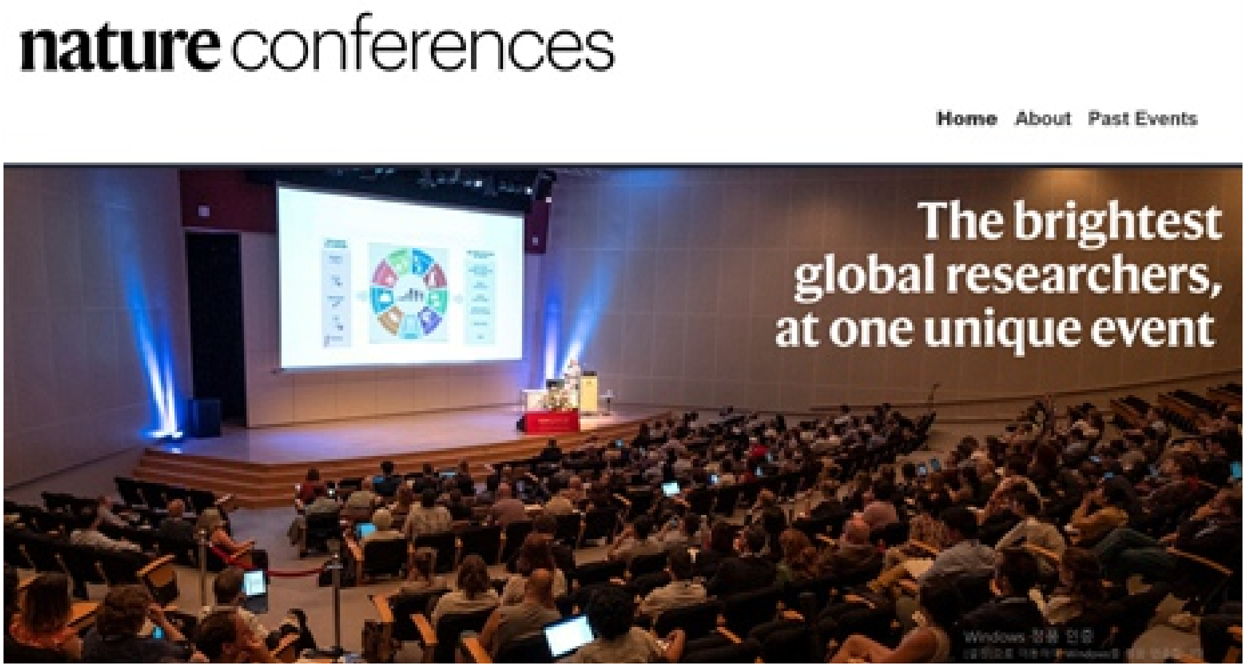
OJERI @ KU OJEong Resilience Institute

ARC ASIA RESILIENCE CENTER

Nature Conference

October 26-28, 2021
Korea University, Seoul, South Korea

Waste Management and Valorisation for a Sustainable Future



Scientific Organizing Committee

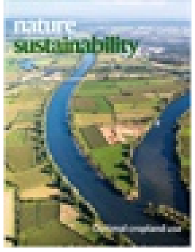
Prof. Yong Sik Ok

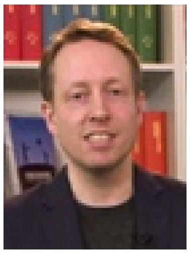
Director, Korea Biochar Research Center
APRU Sustainable Waste Management Program Director Division of Environmental Science and Ecological Engineering
Korea University, South Korea

Monica Contestabile

Chief Editor, Nature sustainability

https://www.nature.com/natsustain/





Owain Vaughan

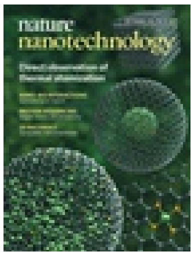
Chief Editor, Nature electronics

https://www.nature.com/natelectron/

Fabio Pulizzi

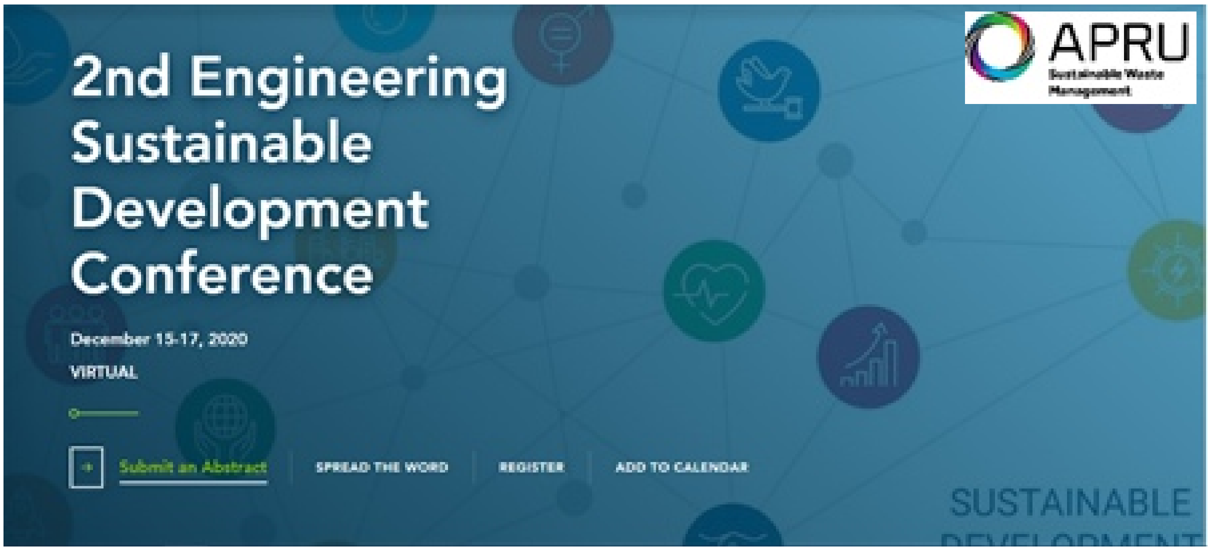
Chief Editor, Nature nanotechnology

https://www.nature.com/nnano/



Engineering Sustainable Development 2020

December 15-17, 2020
VIRTUAL



Engineers, scientists and policy makers will gather to discuss technical and engineering challenges of addressing the 2030 Agenda for Sustainable Development and the 17 Sustainable Development Goals (SDGs).

Conference Chairs:

KOREA UNIVERSITY

Prof. Yong Sik Ok

Director, Korea Biochar Research Center
APRU Sustainable Waste Management Program Director
Korea University, Korea

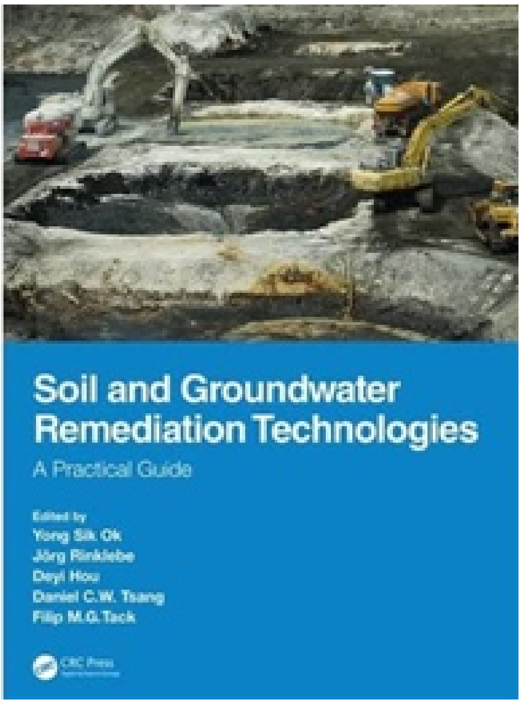
Stanford University

Prof. William Mitch

Full Professor
Stanford University, USA

Soil and Groundwater Remediation Technologies: A Practical Guide

Edited By Yong Sik Ok, Jörg Rinklebe, Deyi Hou, Daniel C.W. Tsang, Filip M.G. Tack



eBook Published: 23 March 2020
Pub. Location: Boca Raton
Imprint: CRC Press
DOI: https://doi.org/10.1201/9780429322563
Pages: 350 pages
eBook ISBN: 9780429322563
Subjects: Earth Sciences, Environment & Agriculture, Environment and Sustainability

This book offers various soil and water treatment technologies due to increasing global soil and water pollution. In many countries, the management of contaminated land has matured, and it is developing in many others. Topics covered include chemical and ecological risk assessment of contaminated sites; phytomanagement of contaminants; arsenic removal; selection and technology diffusion; technologies and socio-environmental management; post-remediation long-term management; soil and groundwater laws and regulations; and trace element regulation limits in soil. Future prospects of soil and groundwater remediation are critically discussed in this book. Hence, readers will learn to understand the future prospects of soil and groundwater contaminants and remediation measures.

Key Features:

- Discusses conventional and novel aspects of soil and groundwater remediation technologies
- Includes new monitoring/sensing technologies for soil and groundwater pollution
- Features a case study of remediation of contaminated sites in the old, industrial, Ruhr area in Germany
- Highlights soil washing, soil flushing, and stabilization/solidification
- Presents information on emerging contaminants that exhibit new challenges

This book is designed for undergraduate and graduate courses and can be used as a handbook for researchers, policy makers, and local governmental institutes. Soil and Groundwater Remediation Technologies: A Practical Guide is written by a team of leading global experts in the field.

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

CONTENTS

Welcome Message

It is our great pleasure to welcome you for the 20th International Conference on Heavy Metals in the Environment (ICHMET 2020) which will be held from 25th-29th October 2020 as a hybrid event. The Korea Biochar Research Center and Korea University will host this conference together with the University of Wuppertal in Germany, University of Queensland in Australia, Ghent University in Belgium, Foshan University, China Jiliang University, Northwest A&F University and Henan Agricultural University in China.

The International Conference on Heavy Metals in the Environment is the oldest and one of the largest conferences on heavy metals which provides an integrated perspective on research, technology and management of all aspects of heavy metals in a trans-disciplinary context. This conference will provide a unique platform for sharing knowledge on state-of-the-art research activities in all aspects of heavy metals among a broad international scientific community, policy makers and industrial personnel.

We would be delighted to have you on this momentous occasion to share your scientific ideas and celebrate with us!

Chair, Prof. Yong Sik Ok

Full Professor, Director
2018, 2019 Web of Science Highly Cited Researcher
Research Director (Global)
Director APRU SWM
Korea Biochar Research Center
Division of Environmental Science and Ecological Engineering
Korea University
Seoul, Korea
Web: http://yongsikok.korea.ac.kr/
APRU SWM: https://apru.org/our-work/pacific-rim-challenges/sustainable-waste-management/

Conference Chairs

Chair

Prof. Yong Sik Ok

Korea University
Korea

Co-Chair

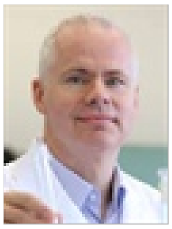
Prof. Jörg Rinklebe

University of Wuppertal
Germany

Co-Chair

Prof. Longbin Huang

The University of Queensland
Australia



Co-Chair

Prof. Filip Tack

Ghent University
Belgium

Co-Chair

Prof. Nanthi Bolan

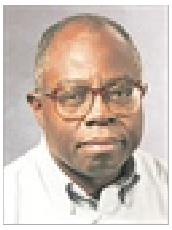
The University of Newcastle
Australia

Co-Chair

Prof. Hailong Wang

Foshan University
China

ICHMET Committee



Prof. Jerome Nriagu
(ICHMET founder)
University of Michigan
USA

Prof. Nicholas Basta
Ohio State University
USA

Prof. Nanthi Bolan
The University of Newcastle
Australia

Dr. Fanny Coutelot
University of Georgia
USA

Prof. Xinbin Feng
Chinese Academy of Sciences
China

Prof. Gijs Du Laing
Universiteit Gent
Belgium

Prof. Sophie Ayrault
Laboratoire des Sciences du Climat et de l' Environnement
France

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University of Vienna
Austria

Prof. Claude Boutron
Joseph Fourier University
France

Prof. Anna Knox
Savannah River National Laboratory
USA

ICHMET Committee

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International Graduate School Zittau
Germany

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University of Connecticut
USA

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University of Freiberg
Germany

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Korea University
Korea

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Arche-consulting
Belgium

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Norwegian Institute for Air Research
Norway

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Institute of Atmospheric Pollution Research
of the CNR
Italy

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The University of Georgia
USA

Prof. Magdi Selim
Louisiana State University
USA

Prof. Eiliv Steinnes
Norwegian University of Science
and Technology
Norway

ICHMET Committee

Prof. Elsie Sunderland
Harvard School of Public Health
USA

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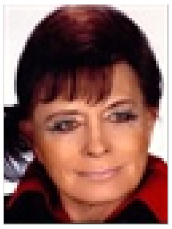
Ghent University
Belgium

Prof. Piotr Szefer
Medical University of Gdansk
Poland

Prof. Jörg Rinklebe
University of Wuppertal
Germany



Prof. Irena Twardowska
Polish Academy of Sciences
Poland

Prof. Erik Meers
Ghent University
Belgium

Plenary Speakers

Prof. Jörg Rinklebe
University of Wuppertal
Germany

Prof. Barry Noller
The University of Queensland
Australia

Prof. Nanthi Bolan
The University of New Castle
Australia

Prof. Filip Tack
Ghent University
Belgium

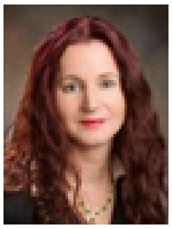
Prof. Daniel S. Alessi
University of Alberta
Canada

Prof. Longbin Huang
The University of Queensland
Australia

Prof. Michael S. Bank
Institute of Marine Research
Norway

Prof. Jochen Bundschuh
University of Southern Queensland
Australia

Prof. Deyi Hou
Tsinghua University
China



Dr. Anna Sophia Knox
Savannah River National Laboratory
USA

Plenary Speakers

Prof. Shengsen Wang
Yangzhou University
China

Prof. Peifang Wang
Hohai University
China

Prof. Daniel Tsang
Hong Kong Polytechnic University
Hong Kong

Prof. Amit Bhatnagar
LUT University
Finland

Keynote Speakers

Prof. Franz Jirsa
University of Vienna
Austria

Prof. Dar-Yuan Lee
National Taiwan University
Taiwan

Prof. Shiming Ding
Nanjing Institute of Geography and Limnology
China

Prof. Xing-mei Liu
Zhejiang University
China

Prof. Jim Ippolito
Colorado State University
USA

Prof. Prosun Bhattacharya
KTH Royal Institute of Technology
Sweden

Prof. Zengqiang Zhang
Northwest A&F University
China

Prof. Muhammad Farooq
Sultan Qaboos University
Oman

Dr. Mukesh Kumar
Northwest A&F University
China

General Information

ORAL SESSIONS

All video presentations are played through the online presentation platform.

[Presentation Time]

Presentation	Time
Plenary Speech	20 min
Keynote Speech	20 min
Real-time Presentation	20 min
Oral Presentation	10 min

POSTER SESSIONS

Poster presentations are showed through the online presentation platform.

PROCEEDINGS

Proceedings (PDF file) is posted at the conference website.

TOPICS

- Metals and human health.
- Metals-microbe interactions.
- Risk assessment and remediation of metal contaminated sediments and flooded soils.
- Cycling of Heavy Metal: The hydrologic process and ecological effect.
- Advances in heavy metal remediation technology.
- Metals/metalloids in sediment-water systems.
- Metal(loid)s in Metal Mine Environments: biogeochemical processes and mineralogical immobilization.
- Metal contents in cultivated crops: nutritional needs versus food safety.
- Management of land affected by diffuse metal contamination: taking control.
- Interaction of metal (oxyhydroxide) nanoparticles with potential toxic metals: mechanisms and optimization.
- Plant micronutrient nutrition for better yield and combating malnutrition.
- Ionic liquids: a greener alternative for heavy metal recovery from aqueous solutions.
- Metals in the circular economy: novel, sustainable technologies for metal recovery from low-grade ores and wastes.
- Adsorption of heavy metals on biomaterials.
- SMART biochar technology: A shifting paradigm towards advanced materials and healthcare research.
- Mitigating the global arsenic problem for contributing to meet the 2030 SDGs.
- Mercury in the environment: cycling, fate, and health risk

Program at a Glance

Date/Time	October 26 (Mon)		October 27 (Tue)	October 28 (Wed)
	Room 1	Room 2		
10:00-11:00	Opening Ceremony	Oral Session 1	Oral Session 9	Oral Session 12
	Plenary Speech		Oral Session 10	
11:00-12:00	Introduction on Special Issue	OralSession2	Special Workshop	Oral Session 12
		Oral Session 3		Oral Session 13
12:00-14:00	Lunch	Lunch	Lunch	Lunch
14:00-15:00	Plenary Speech	Oral Session 4	Oral Session 11	Oral Session 14
15:00-16:00	Plenary Speech	OralSession5		
		Oral Session 6	Break with coffee and fruit	Break with coffee and fruit
16:00-17:00	Plenary Speech	Break with coffee and fruit	Online discussion session	Plenary Speech
	Break with coffee and fruit	Oral Session 7		Oral Session 15
	Plenary Speech	Oral Session 8		
17:00-18:00	Keynote Speech			Oral Session 16
18:00-22:00	Banquet	Banquet	Banquet	Banquet

Banquets will be held with a small number of participants according to government guidelines.

Program Timetable

■ October 26 (Monday)

Room 1

10:00-10:10	Prof. Yong Sik Ok *(Korea University, Korea)* Prof. Jörg Rinklebe *(University of Wuppertal, Germany)* Prof. Filip Tack *(Ghent University, Belgium)* Prof. Longbin Huang *(The University of Queensland, Australia)* Welcome Address **Opening Ceremony**
10:10-10:30	Prof. Jörg Rinklebe *(University of Wuppertal, Germany)* (Im)mobilization of heavy metals in soils and sediments using biochars **Plenary Speech**
10:30-10:50	Prof. Filip Tack *(Ghent University, Belgium)* Sustainable risk-based management of heavy metal contaminated land **Plenary Speech**
10:50-11:10	Prof. Nanthi Bolan *(The University of New Castle, Australia)* Heavy Metal Bioavailability and Human Health **Plenary Speech**

Introduction on Special Issue

11:10-11:15	Prof. Shengsen Wang *(Yangzhou University, China)* Carbon supported metal-based nanoparticles for detoxification of potential toxic metals: mechanisms, optimization, and application **Journal of Hazardous Materials**
11:15-11:20	Prof. Nanthi Bolan *(The University of New Castle, Australia)* Heavy metal bioavailability and human health **Journal of Hazardous Materials**
11:20-11:25	Prof. Nanthi Bolan *(The University of New Castle, Australia)* Soil Health and Recycling of Organic Resources **Soil Use and Management**
11:25-11:30	Prof. Huy Dang *(Trent University, Canada)* Environmental Fate and Effects of Technology Critical Elements **Archives of Environmental Contamination and Toxicology**
11:30-11:35	Dr. T. Komang Ralebitso-Senior *(Liverpool John Moores University, UK)* Production and Application of Biochar to Underpin Select Sustainable Development Goals **Cogent Environmental Science**
11:35-11:40	Prof. Daniel C.W. Tsang *(The Hong Kong Polytechnic University, Hong Kong, China)* Green Stabilization/Solidification of Hazardous Wastes **Environmental Pollution**

11:40-12:00	Prof. Jim Ippolito *(Colorado State University, USA)* Introduction for ICHMET / ICOBTE conference in June 2022
12:00-14:00	**Lunch**
14:00-14:20	Prof. Daniel Alessi *(University of Alberta, Canada)* Mechanisms of metals cycling in meromictic mine pit lakes **Plenary Speech**
14:20-14:40	Prof. Jochen Bundschuh *(University of Southern Queensland, Australia)* The role of the global arsenic problem within the UN 2030 Sustainable Development Goals (SDGs) and UNESCO Priorities **Plenary Speech**
14:40-15:00	Dr. Anna Sophia Knox *(Savannah River National Laboratory, USA)* New Approaches in Remediation of Contaminated Sediments **Plenary Speech**
15:00-15:20	Prof. Michael S. Bank *(Institute of Marine Research, Norway)* Methylmercury in Seafood: An Information Theoretic Approach **Plenary Speech**
15:20-15:40	Prof. Shengsen Wang *(Yangzhou University, China)* Biochar enhanced electron transfer of zerovalent iron: Importance of biomass constituents **Plenary Speech**
15:40-16:00	Prof. Deyi Hou *(Tsinghua University, China)* Sustainable soil use and management **Plenary Speech**
16:00-16:20	Prof. Daniel Tsang *(The Hong Kong Polytechnoc University, Hong Kong, China)* Low-Carbon Stabilization of Arsenic and Lead Contaminated Soil/Sediment **Plenary Speech**
16:20-16:40	**Break with coffee and fruit**
16:40-17:00	Prof. Peifang Wang *(Hohai University, China)* Cycling of Heavy Metals: The Hydrologic Process and Ecological Effect **Plenary Speech**
17:00-17:20	Prof. Jim Ippolito *(Colorado State University, USA)* A Connection Between Soil Health, Plant Productivity and Quality, and Mine Land Reclamation Success **Keynote Speech**
17:20-17:40	Prof. Franz Jirsa *(University of Vienna, Austria)* Ionic liquids: a greener alternative for metal extraction from aqueous solutions? **Keynote Speech**
17:40-18:00	Prof. Dar-Yuan Lee *(National Taiwan University, Taiwan)* Comparison of Arsenic Accumulation and Speciation in Water Spinach Grown in Flooding vs. Upland Soils **Keynote Speech**

18:00-18:20 Prof. Shiming Ding *(Nanjing Institute of Geography and Limnology, China)*
Measuring Biogeochemical Heterogeneity at the Micro-scale in Soils/Sediments: Diffusive Gradients in Thin Films and Planar Optodes
Keynote Speech

18:20-18:40 Prof. Xing-mei Liu *(Zhejiang University, China)*
Insights of human health risks into soil management
Keynote Speech

18:40-19:00 Prof. Muhammad Farooq *(Sultan Qaboos University, Muscat, Oman)*
Micronutrient nutrition in crop plants for better yield and combating malnutrition
Keynote Speech

19:00-19:20 Prof. Prosun Bhattacharya *(KTH Royal Institute of Technology, Sweden)*
Arsenic as a global geogenic contaminant affecting drinking water quality and public health
Keynote Speech

19:20-19:40 Prof. Zengqiang Zhang *(Northwest A&F University, China*
Streptomyces pactum Act12 assisted phytoremediation of Cd and Zn contaminated soils by potherb mustard
Keynote Speech

19:40-20:00 Dr. Mukesh Kumar *(Northwest A&F University, China)*
How heavy metal resistant fungal communities and their interaction with physicochemical parameters influence by biochar amendment during poultry manure composting
Keynote Speech

18:00-22:00 Banquet

■ October 26 (Monday)

Room 2

Session 1 SMART biochar technology: A shifting paradigm towards advanced materials and healthcare research

S1-OP1 **10:10-10:20**
Feedstock type and production temperature interactively affect hydrochar adsorption capacity for lead in aqueous solutions
Scott Chang
University of Alberta, Canada

S1-OP2 **10:20-10:30**
Aqueous Cr (VI) removal by a novel ball milled Fe0–biochar composite: Role of biochar electron transfer capacity under high pyrolysis temperature
Jingchun Tang
Nankai University, China

S1-OP3

10:30-10:40

Co (II)–catalyzed biomass conversion for simultaneous production of 5–hydroxymethylfurfural enriched bio–oil and biochar–stabilized Co nanoparticles

WuJun Liu
University of Science & Technology of China, China

S1-OP4

10:40-10:50

Effects of ball milling on the photochemistry of biochar: Enrofloxacin degradation and possible mechanisms

Honghong Lyu
Hebei University of Technology, China

S1-OP5

10:50-11:00

Synthesis of humins–derived biochar catalyst from rice waste valorisation for glucose isomerization

Shanta Dutta
The Hong Kong Polytechnic University, Hong Kong, China

S1-OP6

11:00-11:10

Amino functionalized invasive plant derived biochar for sorptive removal of hexavalent chromium in aqueous media–Effect of pH

Vishma Perera
Sabaragamuwa University, Sri Lanka

Session 2 Metals and human health

S2-OP1

11:10-11:20

Environmental and health impacts of heavy metal(loid)s from mine waste through bioaccessibility and leaching studies

Jillian Helser
KU Leuven, Belgium

S2-OP2

11:20-11:30

Human whole blood, fingernails, and hair as biomarkers of exposure to trace metals near an urban/industrial mixed area

Bohdana Markiv
University of Cantabria, Spain

S2-OP3 **11:30-11:40**
Co–selective pressure of antibiotic resistance genes and heavy metals pollution in the soil
Zheng Qi
Harbin University of Commerce, China

Session 3 Cycling of heavy metal: The hydrologic process and ecological effect

S3-OP1 **11:40-11:50**
Effects of neutral sewage sludge biochar on Cd enrichment by paddy and greenhouse gas emission in acidic Cd contaminated soil
Qiyuan Sun
Fujian Normal University, China

S3-OP2 **11:50-12:00**
Effect of Cadmium bioavailability on its transfer along the terrestrial food chain
Yi Min Wang
Hohai University, China

12:00-14:00
Lunch

Session 4 Management of land affected by diffuse metal contamination: Taking control

S4-OP1 **14:00-14:10**
Assessing potential toxic element risk of rock farming to the food chain
Binoy Sarkar
Lancaster University, United Kingdom

S4-OP2 **14:10-14:20**
Baseline concentrations and spatial variability of Cadmium and Lead in surface soils in a selected Agro–climatic Region in Sri Lanka
Chammi P. Attanayake
University of Peradeniya, Sri Lanka

S4-OP3 **14:20-14:30**
Long–term behaviour of trace elements in excavated earths naturally contaminated in Molybdenum and Selenium after stabilization
Maxime Brandely
Bouygues Travaux, Lyon, France

S4-OP4

14:30-14:40
Application of sustainable drainage system for hydrology and water quality improvement in subtropical regions

Mingjing He
The Hong Kong Polytechnic University, Hong Kong, China

S4-OP5

14:40-14:50
Prediction of potentially toxic elements immobilization efficiency in biochar amended soils: Machine Learning exploration

Kumuduni N. Palansooriya
Korea University, Korea

S4-OP6

14:50-15:00
Phytomanagement of Trace Element contaminated site by *Malva sylvestris* to produce a natural dye: a plot experiment

Alexandre Perlein
University of Ghent, Belgium

Session 5 Mercury in the environment: Cycling, fate and health risk

S5-OP1

15:00-15:10
Mercury contamination and microbial community in wetland sediments

Mitsuo Yoshida
Environmental Research Laboratory, Japan

S5-OP2

15:10-15:20
Study on Hg0 removal performance of carbon–based sorbent derived from coal liquefaction residue raffinate slag

Huijun Chen
Taiyuan University of Technology, China

S5-OP3

15:20-15:30
Evaluation of total cumulative atmospheric deposition of Hg loads with the use of ombrotrophic peatlands as archival records

Irena Twardowska
Inst. of Environ. Engineering, Polish Acad. of Sci, Poland

Session 6 Risk assessment and remediation of metal contaminated sediments and flooded soils

S6-OP1

15:30-15:40
Mechanism of cadmium tolerance and accumulation in submerged macrophytes for contaminated sediment phytoremediation
Li Tao
Hohai University, China

S6-OP2

15:40-15:50
Mobility of heavy metals and ecotoxicity of bottom sediment amended with waste materials
Agnieszka Baran
University of Agriculture in Krakow, Poland

S6-OP3

15:50-16:00
Efficacy and microbial responses of biochar–nanoscale zero–valent ion composite for Cd immobilization in sediments
Qunqun Liu
Chinese Academy of Sciences, China

S6-OP4

16:00-16:10
Interactive effects of zinc nutritional status and salinity stress on productivity, andioxidative response and grain zinc concentration in wheat
Abdul Rehman
Dankook University, Korea

S6-OP5

16:10-16:20
Arsenic contamination in groundwater along different floodplains of Pakistan
Nabeel Niazi
University of Agriculture Faisalabad, Pakistan

16:20-16:40
Break with coffee and fruit

Session 7 Interaction of metal (oxyhydroxide) nanoparticles with potential toxic metals: Mechanisms and optimization

S7-OP1

16:40-16:50

Rapid colorimetric tests for Hg^{2+} and Cd^{2+} ions in water samples with the use of thiol–covered gold nanoparticles

Anna Berlina

Research Center of Biotechnology RAS, Russian Federation

Session 8 Mitigating the global arsenic problem for contributing to meet the 2030 SDGs

S8-OP1

16:50-17:00

Assessing the veracity of arsenic mobility in soil amended with biochar

Indika Herath

University of Southern Queensland, Australia

S8-OP2

17:00-17:10

Modeling Arsenic–Hazard in the Ganges River delta on a regional–scale: India and Bangladesh

Madhumita Chakraborty

Indian Institute of Technology Kharagpur, India

S8-OP3

17:10-17:20

Using geospatial methods to monitor arsenic variability in gold mining areas of northern Tanzania

Julian Magezi Ijumulana

KTH Royal Institute of Technology, Sweden

18:00-22:00

Banquet

- **October 27 (Tuesday)**

Session 9 Metals in the circular economy: Novel, sustainable technologies for metal recovery from low-grade ores and wastes

S9-OP1

10:00-10:10

Selective copper recovery from ammoniacal waste streams using a systematic biosorption process

Nina Ricci Palma Nicomel

Ghent University, Belgium

S9-OP2

10:10-10:20

Bio–metallurgical process for extraction and recovery of lead from low–grade mineral tailings of zinc refining

Karel Folens

Ghent University, Belgium

S9-OP3

10:20-10:30

Production of a mixed rare earth elements compound using the ashes of the hyperaccumulator D. linearis

Bastien Jally

University of Lorraine - CNRS, France

S9-OP4

10:30-10:40

Agromining of nickel

Marie–Odile Simonnot

University of Lorraine - CNRS, France

S9-OP5

10:40-10:50

Biotechnological strategies for the recovery of technology critical elements from electronic wastes

Eric Van Hullebusch

Université de Paris, France

Session 10 Metals-microbe interactions

S10-OP1

10:50-11:00
Physiologically based pharmacokinetic model for the biotransportation of arsenic in marine medaka (*Oryzias melastigma*)
Wei Zhang
Guangzhou University, China

S10-OP2

11:00-11:10
Effects of Cd, Cu, Zn and their interactions on microbial biomass and bacterial community structure in field and laboratory experiments
Jiuwei Song
Zhejiang University, China

Session Special Workshop

SW-01

11:10-11:30
How to write and publish a scientific paper
Prof. Michael S. Bank
Institute of Marine Research, Norway

SW-02

11:30-11:45
Managing health and environmental effects from contamination of soils with heavy metals and metalloids via mining and agricultural activities
Prof. Barry Noller
The University of Queensland, Australia

SW-03

11:45-12:00
Metal(loid) forms and biogeochemistry in mine wastes
Prof. Longbin Huang
The University of Queensland, Australia

12:00-14:00
Lunch

Session General Session

S11-OP1

14:00-14:10

Gasification biochar from biowaste (food waste and wood waste) for effective removal of radioactive 137-Cs and 90-Sr in aqueous solutions

In-Ho Yoon

Korea Atomic Energy Research Institute, Korea

S11-OP2

14:10-14:20

Application of S-impregnated biochar on methylmercury removal in water and sediment

Yongseok Hong

Korea University Sejong Campus, Korea

S11-OP3

14:20-14:30

Diverse utilizations of biomass biochar over thermochemical processes

Hyungseok Nam

Korea Institute of Energy Research, Korea

S11-OP4

14:30-14:40

Particle size distribution and enrichment of alkali and heavy metals in fly ash on air and oxy condition from sludge combustion

Ha-Na Jang

Yonsei University, Korea

S11-OP5

14:40-14:50

An investigation on adsorption behavior of radioiodine on Hydrotalcitelike clay mineral using extended x-ray absorption fine structure

Sang-Ho Lee

Central Research Institute, Korea

S11-OP6

14:50-15:00

Effective decontamination strategy of radioactive soil: Removal of Cs using soil washing assisted by magnetic separation process

June-Hyun Kim

Korea Atomic Energy Research Institute, Korea

S11-OP7

15:00-15:10

Surface modification of polymeric support materials for immobilization of nano-sized adsorbent for toxic heavy metals

Yuhoon Hwang

Seoul National University of Science and Technology, Korea

S11-OP8

15:10-15:20
Alkali metals corrosions on boiler tube in waste to energy facility

Ha-Na Jang
Yonsei University, Korea

S11-OP9

15:20-15:30
Adsorption characteristics of strontium ions by pristine and magnetic biochars derived from spent coffee grounds

Jaegwan Shin
Kangwon National University, Korea

S11-OP10

15:30-15:40
PGPR aided zinc application improve the productivity and grain biofortification of bread wheat

Dong Jin Lee
Dankook University, Korea

S11-OP11

15:40-15:50
Intrinsic chemical reaction of heavy metals in ice and its environmental implication and application

Kitae Kim
Korea Polar Research Institute (KOPRI), Korea

15:50-16:00
Break with coffee and fruit

Session Online discussion session

16:00-16:30
Meet the guest editors of all the special issues

16:30-17:00
Q&A for “How to write and publish a scientific paper” by Prof. Michael S. Bank

17:00-17:30
Summary of each session by special symposiums chairs and conference chairs

17:30-18:00
Biochar future research trend analysis (Pluto and Scinapse)

18:00-22:00
Banquet

■ October 28 (Wednesday)

Session 12 Metal(loid)s in metal mine environments: Biogeochemical processes and mineralogical immobilization

S12-OP1

10:00-10:10
Chemical and mineralogical heterogeneity of mining waste at Plombieres (East–Belgium)

Valéri Cappuyns
KU Leuven, Belgium

S12-OP2

10:10-10:20
Antimony in soils and mine waste heaps around the Mau Due antimony mine, North–Vietnam

Valerie Cappuyns
KU Leuven, Belgium

S12-OP3

10:20-10:30
Recycling mechanochemically activated sulfidic mining wastes with blast furnace slag as alkali activated materials

He Niu
University of Oulu, Finland

S12-OP4

10:30-10:40
Characteristics and leaching of heavy metal(loid)s from geopolymers produced from mine waste

Jillian Helser
KU Leuven, Belgium

S12-OP5

10:40-10:50
Mobility and oral bioaccessibility of metals from tailing materials of Romania

Cécile Quantin
Université Paris Saclay, France

S12-OP6

10:50-11:00
The Brumadinho dam failure: what can we learn from Pb isotopes measured on suspended material?

Cécile Quantin
Université Paris Saclay, France

S12-OP7

11:00-11:10
Community variation and metal biotransformation of microbes in alkaline copper mine contaminated sediments

Qiusheng Yuan
Hohai University, China

S12-OP8

11:10-11:20
Acidified biochars to improve heavy metal solubility in an alkaline mine–contaminated soil

Shinjiro Sato
Soka University, Japan

S12-OP9

11:20-11:30
Availability and mobility of chromium in ultramafic areas affected by mining activities: An isotopic study

Eric Van Hullebusch
Université de Paris, France

Session 13 Metal contents in cultivated crops: Nutritional needs versus food safety

S13-OP1

11:30-11:40
Intercropping of *Pteris vittata* and maize can simultaneously improve food safety and combat iron malnutrition

Xiaoming Wan
IGSNRR, CAS, China

S13-OP2

11:40-11:50
Phytoremediation of Zn contaminated soil using Alfalfa enhanced by EDDS

Xiaolin Wang
Ghent University, Belgium

S13-OP3

11:50-12:00
Se and Zn biofortification of soybean (*Glycine max*) and enhancing its biochemical functions for the human nutrition improvement in the Se/Zn deficient regions

Irena Twardowska
Inst. of Environ. Engineering, Polish Acad. of Sci, Poland

12:00-14:00
Lunch

Session 14 Advances in heavy metal remediation technology

S14-OP1

14:00-14:10
Phytostabilization potential of *Miscanthus X giganteus* and novel seed–based hybrid on heavy metal contaminated arable land
Jacek Krzyzak
Institute for Ecology of Industrial Areas, Poland

S14-OP2

14:10-14:20
Adsorption of heavy metals to anaerobic ammonium oxidation (anammox) consortia: Implications for heavy metal removal in wastewater treatment system
Yuxia Liu
China University of Petroleum, China

S14-OP3

14:20-14:30
Biochar produced from drinking water sludge and its use for Pb^{2+} adsorption
Yunhui Zhang
Nanyang Technological University, Singapore

S14-OP4

14:30-14:40
Potential of *Lactobacillus spp.* isolated from fermented cocoa to reduce the bioaccessibility of Cd or As
Claudia Rodriguez
National University of Colombia

S14-OP5

14:40-14:50
Efficient immobilization of municipal solid waste incinerator fly ash by phosphate–enhanced calcium aluminate cement
Liang Chen
Hong Kong polytechnic University, Hong Kong, China

S14-OP6

14:50-15:00
Research on single/compound reduction stabilization and its long–term effectiveness of remediation effect of Cr(VI) contaminated soil in seasonall
Renjie Hou
Tsinghua University, China

S14-OP7

15:00-15:10
Green remediation of Cd and Hg contaminated soil using humic acid modified montmorillonite: immobilization performance under accelerated ageing conditions
Liuwei Wang
Tsinghua University, China

S14-OP8 **15:10-15:20**

Assessing the effects of biochar and organic fertilizer on bioavailability and speciation of heavy metals in seasonally–frozen farmland soils

Renjie Hou
Tsinghua University, China

S14-OP9 **15:20-15:30**

Green immobilization of toxic metals using alkaline enhanced rice husk biochar: effects of pyrolysis temperature and KOH concentration

Liuwei Wang
Tsinghua University, China

S14-OP10 **15:30-15:40**

Vanadium Biogeochemistry and Bioremediation

Baogang Zhang
China University of Geosciences China

S14-OP11 **15:40-15:50**

Decrease of arsenic release from paddy soil by encapsulated calcium peroxide (CaO2) nanoparticle and biochar

Hye–Bin Kim
Jeonbuk National University, Korea

S14-OP12 **15:50-16:00**

Treatment of Cesium–contaminated soil through extraction–selective adsorption process

Taesun Kim
Jeonbuk National University, Korea

16:00-16:15
Break with coffe and fruit

Plenary Speech **16:15-16:35**

A comparative study of different biomaterials for the removal of toxic metal ions from water

Prof. Amit Bhatnagar
LUT University, Finland

Session 15 Adsorption of heavy metals on biomaterials

S15-OP1

16:35-16:45
Methylene blue removal from aqueous solutions by different types of standard biochars: Evaluation of process variables
Ondrej Masek
University of Edinburgh, United Kingdom

S15-OP2

16:45-16:55
Preparation of HPCs for removal of antibiotics from water and the adsorption properties
Mengxue Zhang
China Jiliang University, Hangzhou

S15-OP3

16:55-17:05
Application of microalgal–based materials for the removal of hexavalent chromium from water
Ehsan Daneshvar
Lappeenranta-Lahti University of Technology, Finland

Session 16 Metals/metalloids in sediment-water systems

S16-OP1

17:05-17:15
Nano–oxides immobilize Cd, Pb and Zn in mine spoils and contaminated soils and facilitate plant growth
Srimathie P. Indraratne
University of Winnipeg, Canada

S16-OP2

17:15-16:25
Sustainable revitalization of river by instream filtering system
Liang Chen
The Hong Kong Polytechnic University, Hong Kong, China

S16-OP3

17:25-17:35
Dynamic process and coupling mechanism recognition between heavy metals and sulfide in sediments using DGT technique in Yellow River Estuary
Yanqing Sheng
Chinese Academy of Sciences, China

S16-OP4 **17:35-17:45**

Zinc pollution in zones dominated by algae and submerged macrophytes in Lake Taihu

Musong Chen

Nanjing Institute of Geography and Limnology, CAS, China

S16-OP5 **17:45-17:55**

Assessing remobilization characteristics of arsenic (As) in tributary sediment cores in the largest reservoir, China

Li Gao

Beijing Normal University, China

S16-OP6 **17:55-18:05**

A New DGT technique comprised in a hybrid sensor for the simultaneous high resolution 2–D imaging of sulfides, metallic cations, oxyanions and dissolved oxygen

Mingyi Ren

Nanjing Institute of Geography and Limnology, China

S16-OP7 **18:05-18:15**

Isotopic signature of the lead fallout from Notre–Dame de Paris fire: implication for urban contamination assessment

Sophie Ayrault

LSCE-CEA, France

S16-OP8 **18:15-18:25**

Quantification of spatial and temporal variations in antimony fluxes originating from urban areas: a nested catchments study

Sophie Ayrault

LSCE-CEA, France

S16-OP9 **18:25-18:35**

Thallium pollution in sediments response to consecutive water seasons in Three Gorges Reservoir using geochemical baseline concentrations

Dongyu Xu

China Institute of Water Resources and Hydropower, China

S16-OP10 **18:35-18:45**

Nitrogen and phosphorus in overlying waters affect the migration and transformation of sedimental heavy metals

Xiaozhu Liu

University of Chinese Academy of Sciences, China

S16-OP11

18:45-18:55
Lead contamination in sediments in the past 20 years: A challenge for China
Bo Gao
China Institute of Water Resources and Hydropower, China

S16-OP12

18:55-19:05
Valorisation of heavy metal contaminated land by industrial hemp for fiber production
Béatrice De Vos
Ghent University, Belgium

18:00-22:00
Banquet

Poster Presentations

PP-01

The mechanism of cadmium sorption by Sulphur–modified wheat straw biochar and its application cadmium–contaminated soil
Xiaobing Wang
Yangzhou University, China

PP-02

Selective uranium extraction from salt lake brine by amidoximated *Saccharomyces cerevisiae*
Jing Bai
Chinese Academy of Sciences, China

PP-03

Sorption of lead by *Clanis bilineata* larvae skin–derived biochars
Yubo Yan
Chinese Academy of Agricultural Sciences, China

PP-04

Adsorption of Zn in aqueous solutions using starfish (*Asterina pectinifera*) biochar
Deok Hyun Moon
Chosun University, Korea

PP-05

Arsenic (V) removal using the mine waste–derived adsorbent
Erdenechimeg Byambaa
Seoul National University of Science &Technology, Korea

PP-06

Oxidation effects of biochar surface on Cadmium and Chromium sorption and phytotoxicity

Che-Yu Chih

National Chiayi University, Taiwan, Republic of China

PP-07

Porphyrin-based metal-organic frameworks as low-temperature NO2 adsorbent

Jin Shang

City University of Hong Kong, Hong Kong, China

PP-08

A systematic analysis of standard biochars for the removal of ions from wastewater

Mark Leaper

Loughborough University, UK

PP-09

UV-Clicked multithiol functionalized graphene bio-sponge for heavy metal ions adsorption

Pei Lay Yap

The University of Adelaide, Australia

PP-10

Polyethylene imine modified hydrochar adsorption for heavy metals removal from aqueous solution

Tao Zhang

China Agricultural University, China

PP-11

Experimental study on mercury removal and regeneration characteristics of elemental sulfur-modified activated Carbon

Cong Chen

Southeast university, China

PP-12

Incorporation of liquid manure and 7 types of food waste biochar for aided-phytostabilization and their impact on arsenic bioavailability and ammonia emissions in arsenic contaminated soil

Min-Suk Kim

Korea University, Korea

PP-13

Short-term and long-term effect of biochar on Pb immobilization in soils

Han Byeol Lee

Korea University, Korea

PP-14

Visible-light enhanced Cr (VI) reduction in the photocatalysis coupled microbial fuel cell with MXene photocathode

Wenjun Zhao

Guizhou University, China

PP-15 Artificial ageing of amended soils and its impact on Cd speciation in soil solution

Yoann Viala
CELUP, Ireland

PP-16 Inkjet-printed prussian blue-decorated magnetic microparticles for the enhanced removal of cesium from water

Yeonsoo Lee
Korea Atomic Energy Research institute, Korea

PP-17 Assessment of high-pressure soil washing techniques for Pb and Zn contaminated soils

Han Gyeol Jeon
Chosun University, Korea

PP-18 Exogenous nitric oxide promotes cadmium tolerance and accumulation in a high cadmium-accumulating rice (*Oryza saliva L.*) line by promoting polysaccharide synthesis of root cell wall

Huan Yang
Sichuan Agricultural University, China

PP-19 Bioremediation of Cd-spiked soil using earthworms (*Eisenia fetida*): enhancement with biochar and *Bacillus megaterium* application

Xiangyu Liu
Northwest Agriculture & Forestry University, China

PP-20 Selective separation of clay in Cs contaminated soil using flotation with hydrophobic silica nanoparticles

Sung-Man Kim
Korea Atomic Energy Research Institute, Korea

PP-21 Citric acid assisted phytoremediation of lead and mercury by *Taifa Latifolia* L.

Waqas Amir
University of Gujrat, Hafiz Hayat Campus, Pakistan

PP-22 Vanadium biogeochemistry and bioremediation

Baogang Zhang
China University of Geosciences China

PP-23

Selective sorbents for the In-Situ immobilization of I-129, Tc-99 and other contaminants

John Seaman

University of Georgia, USA

PP-24

Ionic surfactant enhancement of clay properties from the basement complex soil of Southwestern Nigeria for heavy metals adsorption in aqueo us medium

Samuel Sunday Asaolu

Ekiti State University, Nigeria

PP-25

Green and novel stabilisation/solidification of Zn by Metakaolin-Based Geopolymer

Lei Wang

Technische Universität Dresden, Germany

PP-26

An oxidation-modified biochar-based composite amendment significantly enhanced Cd adsorption ability

Hua gang Huang

Sichuan Agricultural University, China

PP-27

Insight into the mechanisms involved in the bioremediation of mercury(II)-polluted soil by a novel plant growth promoting strain AN-B15

Jinquan Chen

Yunnan University, China

PP-28

Capacitive deionization of uranium (VI) with novel MOF-derived N-doped hierarchical porous carbon electrodes

Chaohai Wang

Nanjing University of Science and Technology, China

PP-29

Status, source of herb medicine' s heavy metal pollution and its control strategies

Chao Wang

Southern University of Science and Technology, China

PP-30

Comparisons of developmental toxicity of germanium and tellurium in zebrafish (*Danio rerio*) and medaka (*Oryzias latipes*) embryos

Pei-Jen Chen

National Taiwan University, Taiwan

PP-31

Bioaccessibility of trace metal(loid)s in urban dust: effect of the type of synthetic body fluid and liquid to solid ratio

Bohdana Markiv

University of Cantabria, Spain

PP-32

Assessments of metal concentration in maternal blood, placenta and umbilical cord blood and their associated pregnancy outcomes

Shailendra Pratap Singh

Dr. Bhimrao Ambedkar University, India

PP-33

Adsorption of radioactive Cesium by immobilizing Prussian Blue on Polypropylene non–woven filter

Narges Dehbashi

Seoul National University of Science &Technology, Korea

PP-34

Diets and health risks: a new perspective of hazardous heavy metal intake and accumulation in humans

Chengjun Li

Institute of Environmental Research at Greater Bay Area, China.

PP-35

From the age of information technology to the age of psychology – the Superessentiality of chemical element Lithium

Bernd Albert Markert

International Institute of Scientific Networks, Germany

PP-36

Co–release potential and human health risk of heavy metals from pipe scales under stagnation conditions of drinking water

Weigao Zhao

Tianjin University, China

PP-37

Cobalt accumulation pattern in immature mice after subchronic exposure to cobalt chloride – relationship with iron homeostasis

Yordanka Gluhcheva

Bulgarian Academy of Sciences, Bulgaria

PP-38

A ROS defensive mechanism is involved in the rice response to indium stress

Ya–Fen Lin

National Taiwan University, Taiwan

PP-39

Prediction of Cd concentrations in wheat roots by using non-linear BLM

Kai-Wei Juang

National Chiayi University, Taiwan

PP-40

Modelling alleviative effects of Magnesium on Copper-induced oxidative stress in grapevines

Bo-Ching Chen

Nanhua University, Taiwan

PP-41

Potential of trace element accumulation in edible plants using metal accumulation index (MAI): a case study of southern Poland

Agnieszka Gruszecka-Kosowska

AGH University of Science and Technology, Poland

PP-42

Heavy metals in Seaweed: a bio-indicator of metals exposure and environmental pollution

Mayeen Uddin Khandaker

Sunway University, Malaysia

PP-43

Exogenous glutathione promotes cadmium detoxification and retention by regulating various relevant biosynthesis in roots of rice (*Oryza Sativa L.*)

Keji Wang

Sichuan Agricultural University, China

PP-44

Chemicals management issues, with emphasis on geochemical cycles of major metal/loids commonly found in food

Ming Wong

The Education University of Hong Kong, Hong Kong, China

PP-45

Effects of Cadmium and Chromium accumulation in *Pheretima posthuma* (earthworm)

Nazia Ehsan

University of Agriculture Faisalabad, Pakistan

PP-46

Ecotoxicological effects of single and binary mixture of nano-TiO_2 and galaxolide in the radish (*Raphanus sativus*)

Qianru Zhang

Chinese academy of agricultural sciences, China

PP-47 The location distribution of pollutants in burst metal pipe in drinking water distribution system

Shichao Jia
Tianjin University, China

PP-48 Silicon can alleviate the negative effects of soil cadmium pollution on garlic growth, quality, and food safety

Jiamin Xu
Chinese Research Academy of Environmental Sciences, China

PP-49 Characteristics and risk assessment of metal pollution in groundwater and river water in river in a gold mining area

Tao Ma
Chinese Academy of Sciences, China

PP-50 Removal of arsenic (Ⅴ) from aqueous solutions using iron-loaded ceramsite as an applicable adsorbent

Yue Yin
Qingdao University of Technology, China

PP-51 Bioavailability and toxicity assessments for long-term arsenic contaminated river sediment with analytical and toxicological methods

Pei-Jen Chen
National Taiwan University, Taiwan

PP-52 Importance of Al/Fe oxyhydroxide coating and ionic strength in perfluorooctanoic acid (PFOA) transport in saturated porous media

Xueyan Lyu
Nanjing University of Information Science & Tech. China

PP-53 Zinc pollution in zones dominated by algae and submerged macrophytes in Lake Taihu

Musong Chen
Nanjing Institute of Geography and Limnology, CAS, China

PP-54 Removal of Cu (II) ions from aqueous solution using petroleum coke-derived porous carbon: Investigation of adsorption equilibrium and kinetics

Xiangzhou Yuan
Korea University, Korea

PP-55

Heavy metals content in surficial sediments in coastal vicinity of malacca straits

Meng Chuan Ong

Universiti Malasia Terengganu, Malaysia

PP-56

Calculation and application of beryllium toxic factor in the assessment of potential ecological risk index

Yang-Guang Gu

Chinese Academy of Fishery Sciences, China

PP-57

Chemical speciation, spatial distribution and risk assessment of trace metals in the sediments of Laguna De Bay, Philippines

Kimbhierly Ludovice

Graduate Studies Alumina, Philippines

PP-58

Source apportionment of heavy metals in sediments and soils in an interconnected river-soil system based on a composite fingerprint screening approach

Ruihui Chen

Chinese academy of agricultural sciences, China

PP-59

Source identification of Pb in different chemical fractions in sediments from Three Gorges reservoir, China

Lanfang Han

Guangdong University of Technology, China

PP-60

The effect of lithium implementation on trace elements uptake by maize under hydroponic conditions

Jacek Antonkiewicz

University of Agricultural in Krakow, Poland

PP-61

Boron improves productivity and profitability of bread wheat under zero and plough tillage on alkaline calcareous soil

Faisal Nadeem

The University of Haripur, Pakistan

PP-62

Zinc nutrition in Chickpea for improving yield and grain biofortification

Aman Ullah

Sultan Qaboos University, Oman

PP-63

Screening of root system architecture of Wheat (*Triticum aestivum*) cultivars efficient for iron scavenging

Rashida Sultana

University of Agriculture Faisalabad, Pakistan

PP-64

Improving the productivity and grain biofortification of spring Maize (*Zea mays L.*) through Zinc nutrition under drought conditions in changing climate

Muhammad Nawaz

Khwaja Fareed University of Engineering and Inform, Pakistan

PP-65

Alleviation of drought stress in maize hybrid through integrated nutrient management

Sajid Hussain

College of Agriculture, BZU, Pakistan

PP-66

Zinc bio–fortification in wheat through farmyard manure, acidified compost and $ZnSO_4$ amendments

Muhammad Hussain

MNS University of Agriculture, Pakistan

PP-67

Breeding and management tactics for developing Iron biofortified wheat varieties

Abia Younas

Ayub Agricultural Research Institute, Pakistan

PP-68

Exogenous application of Potassium and Salicylic acid modulates the dynamics of salt induced stress responses in different cultivars of rice

Maria Nawaz

University of Gujrat, Pakistan

PP-69

Agronomic biofortification in wheat using glutathione and orgnanic biostimulant under saline condition

Hafeez Rehman

University of Agriculture, Faisalabad

PP-70

Split application of Iron improved yield, net income and grain–iron concentrations of Mungbean (*Vigna radiata*)

Mubshar Hussain

BZU, Multan, Pakistan

PP-71 Seed yield and fatty acid composition in sesame (*Sesamum indicum L.*) as affected by silicon application under a semiarid climate

Ahmad Sher

College of Agriculture, BZU, Layyah, Pakistan

PP-72 Improving the quality and yield performance of Safflower (*Carthamus tinctorius L.*) through foliar application of Selenium

Ahmad Sher

College of Agriculture, BZU, Pakistan

PP-73 Boron seed coating along with microbial seed inoculation improved productivity and grain boron concentration of Chickpea

Mubshar Hussain

BZU, Multan, Pakistan

PP-74 Zinc nutrition for improving the productivity and grain biofortification of Mungbean

Ahmad Nawaz

College of Agriculture, BZU, Pakistan

PP-75 Poultry–mortality compost as an option to eliminate micronutrient malnutrition in humans

Abdul Wakeel

University of Agriculture Faisalabad, Pakistan

PP-76 Responses of micronutrients bioavailability to elevated ozone exposure in a flooded rice paddy system

Yabo Wang

Nanjing University, China

PP-77 Removal of Acid Orange 7 (AO7) dye from water by a magnetic red mud–derived biochar

Kun Lin

China JiLiang university, China

PP-78 The performance of transition metal doped biochar as SCR catalyst

Yun Shi

Zhejiang University of Science and Technology, China

PP-79

Removal of As(V) and phenanthren from wastewater by zirconium nanopartilces hybrid magnetic kitchen waste biochar composite

Ronghua Li
Northwest A&F University, China

PP-80

Characterization of soil pore structure of paddy soils under long-term rice straw biochar incorporation

Ning Anning
Shenyang Agricultural University, China

PP-81

Earthworms activities weaken the immobilizing effect of biochar as amendment for metal polluted soils

Jie Wang
Nanjing Agricultural University, China

PP-82

Evaluating biochar and its modifications for the removal of ammonium, nitrate, and phosphate from aqueous environments

Ming Zhang
China Jiliang University, China

PP-83

Short- and long-term biochar Cadmium and Lead immobilization mechanisms

Liqiang Cui
Yancheng Institute of Technology, China

PP-84

Application of biochar from wood and livestock waste mixture for energy supply and odor control

Ijung Kim
Hongik University, Korea

PP-85

Potential risk of metal halide perovskite solar cells in the environment: a critical review

Pavani Dissanayake
Korea University, Korea

PP-86

Effect of biochar on immobilization of Pb in perovskite solar cell contaminated soils

Hee Chan Jo
Korea University, Korea

PP-87

Stabilization of multi metals-contaminated soil using rice straw biochar and phosphate

Suyeon Kim
Jeonbuk National University, Korea

PP-88 Heavy metal immobilization and nutrient release by standard biochars

Yoora Cho

Korea University, Korea

PP-89 Effects of gallium and indium on soil bacterial diversity

Nai-Chun Lin

National Taiwan University, Taiwan

PP-90 Characterization of the technology-critical elements (TCEs)-resistance mechanism of *Luteibacter* sp. PCI1001 using a genome-wide approach

Chieh Ling Liao

National Taiwan University, Taiwan

PP-91 Removal of hexavalent chromium by *Aspergillus niger* through reduction and accumulation

Hui Xu

Peking University, China

PP-92 Enhanced Cd remediation of magnetic biochar in soils and water by *Bacillus* sp. K1 and their influence on soil microbial community.

Jorge L. Mazza Rodrigues

University of California - Davis, USA

PP-93 Removal of Cd (II) and As (III) from aqueous solution by biochar-supported nanoscale zero-valent iron: Characterization and remediation mechanism

Dong Yang

Zhejiang University, Chian

PP-94 Assessment of bacterial communities and characterization of multi-metal resistant bacteria in the rhizosphere soils of phytostabilizer *Athyrium wardii* (Hook.) grown in a lead-zinc mine tailing

Yun Hong Zhang

Sichuan Agricultural University, China

PP-95 Mechanistic explanation for time-dependent hormetic effect of heavy metal on *Scenedesmus obliquus*

Ling Yun Mo

Guilin University of Technology, China

PP-96 Characterization of metal – microalgae flocs based on ImageJ image software in harvesting process

Jun Sha

Chinese Academy of Sciences, China

PP-97 Use of *Yarrowia lipolytica* yeast to immobilize heavy metals in soil fertilized with waste

Jacek Antonkiewicz

University of Agriculture in Krakow, Poland

PP-98 Microplastics in sediments: occurrences, accumulation of organic contaminants and risks

Ruyi Sun

China JiLiang university, China

PP-99 The degradation performance of different microplastics and their effect on microbial community during composting process

Yue Sun

Northwest A&F University, China

PP-100 The effects of the configurations of microbial fuel cell on its Ammonium removal performance in constructed wetland

Jinye Li

China Jiliang University, China

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Muhammad Mahroz Hussain
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ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Plenary Lectures

PL-1

(Im)Mobilization of Heavy Metals in Soils and Sediments Using Biochars

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Healthy food production is imperative for human health. However, many wetland soils are polluted with toxic elements such as arsenic, cadmium, mercury, antimony and others. In particular, paddy soil are very vulnerable since they serve as producer of food, including rice. Paddy soils are regularly flooded and thus, they underlie large fluctuations of redox conditions. Those changes of redox conditions have considerable impacts on the biogeochemical behavior of toxic elements as well as on pH, carbonate, and carbon solubility, chemistry of iron, manganese, and sulfur as well as on microbial community, which control the mobilization of toxic elements. Doubtless, the redox potential and pH are master variables in governing those mobilization processes. We are able to conduct experiment in the laboratory to study mechanistically the release dynamics of toxic elements. Also, we are seek for suitable amendments to stabilize those toxic metals in the soil which should be stabile even under dynamic redox conditions. Biochar is considered as one option to fulfill this purpose. Various results gained at several scales (microscale, laboratory and field scale) will be presented.

Keywords: soil, sediment heavy metal, biochar, redox

PL-2

Sustainable Risk-Based Management of Contaminated Land: Keeping Heavy Metals under Control

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Mining and use of metals in the human society have led to the dispersal of metals in the global environment, adding to their natural background concentrations. Contamination of land with heavy metals is of concern for environmental and public health. Awareness of the issue rose in the early eighties, and soil remediation using intensive treatments through digging, pumping, burying, and burning, was attempted. It was soon realised that the excessive costs and large negative environmental impacts associated with conventional soil remediation made it virtually impossible to proceed fast and effectively with the clean up of legacy contamination. A paradigm shift occurred where focus moved to risk management involving more sustainable approaches based on recycling, reusing, transforming, and biodegrading. In sustainable risk-based contaminated land management, decisions on contaminated land are made based on risks to environmental and public health. The risk management must meet sustainable development principles and consider all of the three elements of sustainability, i.e., environmental, economic, and social. As elements, heavy metal contaminants in the soil can never be destroyed. Thus, sustainable risk-based management of heavy metal contaminated land has to account for their eternal persistence. A general increase in the risk of mobilisation, leaching and uptake of trace metals by biota is related to their total content in soils although actual mobility is strongly related to the physico-chemical forms present and the local environmental conditions. Options for the management of metal contaminated land will differ according to these factors, but also be shaped as a function of site specific social and economic needs and opportunities. Whatever strategy that is selected ultimately must ensure control of the risks to environmental and public health. Legacy metal contamination remains in the land for a very long time, in principle requiring a virtually eternal aftercare and stewardship. The price to pay by the future society to manage legacy contamination thus is very high and should urge us even more to strive to absolutely prevent any future contamination by heavy metals.

Keywords: soil remediation, metal contamination, phytomanagement

PL-3

Heavy Metal Bioavailability and Human Health

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Several metals, such as iron, cobalt, copper, manganese, molybdenum, and zinc are needed at certain concentration levels by the human body, while other potentially toxic metals such as lead, cadmium, mercury and arsenic have no major beneficial influence on human health. Historically, toxicity of metals to human health received attention primarily as a result of series of widespread poisoning. For example, the hundreds of tragic cases of human poisoning of Minamata Bay in Japan (Minamata disease) in the late 1950s were believed to have occurred from the ingestion of fish containing methyl mercuric compounds. More recently, significant adverse impacts of arsenic on human health have been recorded in Bangladesh, India, and China. The toxicity of ingested contaminants, including heavy metals, is determined ultimately by the extent to which they are solubilised in the gut (bioaccessibility), their permeability through intestinal epithelial cells and subsequent circulation in the blood (bioavailability), and their assimilation and metabolic action in any tissues that subsequently absorb them (bioactivity). The bioaccessibility-bioavailability-bioactivity continuum (Figure 1) plays a critical role in the toxicity of heavy metals to biota. Toxicity of heavy metals can be mitigated by reducing their permeability in the intestine, thereby reducing their entry into the systemic circulation. This presentation will address recent research on the bioavailability of toxic metals in relation to their intestinal permeability, and subsequent toxicity to human health.

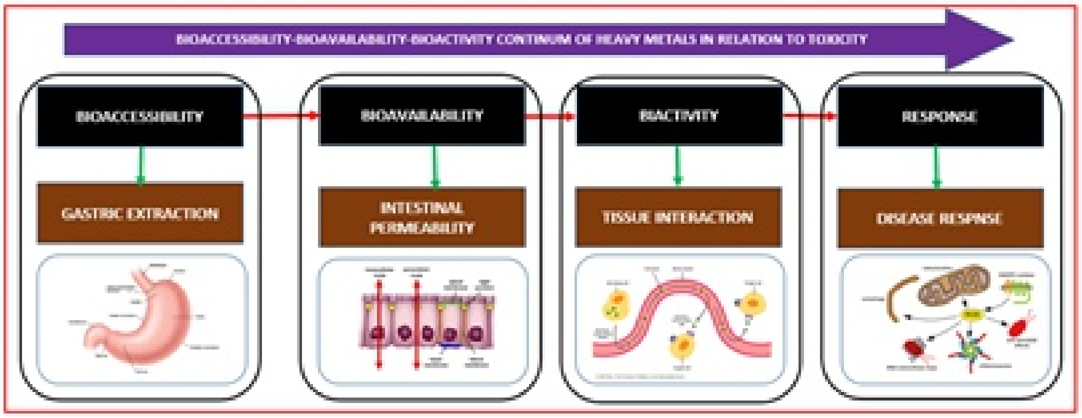

Figure 1. Bioaccessibility-bioavailability-bioactivity continuum

Keywords: Bioaccessibility, bioavailability, bioactivity, toxicity

PL-4

Mechanisms of Metals Cycling in Meromictic Mine Pit Lakes

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Flooded mine pits often become permanently stratified, meromictic water bodies that are comprised of an upper, mixed layer (mixolimnion) and a lower layer that does not mix seasonally (monimolimnion). The development of a permanently-reduced zone at the bottom of pit lakes is touted as a passive method to stabilize potentially toxic metals at mine sites, as the redox gradient between the two layers controls the speciation and fate of numerous redox-active metals. In order to uncover the mechanisms of metals cycling and sequestration, we investigated the cycling of U, As, and Ni in two meromictic pit lakes of different ages and with differing geochemistry located at a former uranium mining site in northeastern Saskatchewan, Canada. Combined use of electron microscopy, ultrafiltration, and asymmetric flow field-flow fractionation revealed that in the water columns of both pits, U and Ni were primarily present as dissolved species or were sorbed onto small colloidal particles (< 10 kDa), despite considerable differences in aqueous chemistry between the pits. In the older and shallower pit, the sharp redox gradient at the intersection of the oxygenated mixolimnion and reduced monimolimnion resulted in primarily tetravalent U species at greater depth generated primarily by Fe(II) oxidation in the water column. In both pits, we observed the “colloidal pumping” mechanisms that demonstrated that with time, colloids agglomerated into larger ones that were more likely to precipitate and transport bound metals/metalloids to the bottom sediments. Synchrotron-based Laue diffraction and XANES identified uraninite alteration products, including vandendriesscheite and gauthierite (both being U(VI) oxyhydroxides), in pit floor sediments; however, many U(IV)-rich grains in the sediment did not exhibit diffraction patterns, indicating the potential presence of non-crystalline U(IV) species. Non-crystalline U(IV) is typically easier to oxidize than solid-phase U(IV) minerals, generating U(VI) species that are more soluble and mobile in groundwater. Our results suggest that characterization of colloid-bound metals, which may pass through standard 0.45 μm membranes and be interpreted as dissolved species, is essential to understanding the cycling and fate of trace metals in mine pits that undergo decommissioning.

Keywords: uranium, arsenic, meromixis, pit lakes, mining

PL-5

The Role of the Global Arsenic Problem within the UN 2030 Sustainable Development Goals (SDGs) and UNESCO Priorities

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It took over a century, recognizing and reporting the contamination of water resources by arsenic (As) as a global problem. However, research on As is still insufficient and the mitigation is inadequate so that it opens the door for a Global Umbrella to implement the principles of science for the society involving capacity building, global networking such as South-South and North-South collaboration, awareness creation, innovative and improved mitigation technologies and endorsing women in science/engineering and decision making. By today, we know that globally at least 100 countries are directly affected by As from mostly geogenic origin that especially contaminates groundwater sources used for drinking and irrigation. The As itself in drinking water at toxic levels has been a risk for more than 200 million people. However, not only these As-affected areas, but also the import of food from As-affected to non-affected areas is of particular concern in terms of human health risks. For example, import of rice containing high As contents from As affected regions has become a global health concern. Further, the exposure to As through gases from coal combustion, e.g. in coal power plants, domestic coal combustion, hydrocarbon and geothermal exploitation and related processing activities together with natural events as volcanic events and bushfires has been a critical issue.

“Arsenic in the environment” is a transdisciplinary array of themes comprising mostly geogenic As and its speciation in water, food, house dust, atmosphere as well as its implications for human health. Mitigation of health, ecological and economic issues associated with As contributes to different extents directly or indirectly for achieving most of the 2030 SDGs of the United Nations. These include water, food, health, poverty/hunger, gender, economics, education/information, justice/equality, quality of life (in aquatic systems and on land), energy/climate change and economics. It is also directly related to the UNESCO Priorities.

In this presentation, we showcase the respective links of the global As problems and indicate a holistic approach for mitigating the global As problem in different systems. This includes global scale actions as an urgent necessity in research, training and knowledge dissemination related to the global As problem including, scientific aspects and mitigation strategies. Approaches must further connect with socio-economic and environmental issues, contributing to human development at national, regional and global levels.

Keywords: Arsenic; groundwater; environment; rice; social and economic aspects; mitigation

PL-6

New Approaches in Remediation of Contaminated Sediments

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Contaminated sediment site management requires lowering chemical risks to ecological receptors and human health via the removal, elimination, or reduction of contaminant release and uptake. Currently the most commonly used methods to remediate metal contaminated sediments are environmental dredging (85%), followed by monitored natural recovery (6%) and capping (6%). Combinations of technologies are often emphasized for the management of contaminated sediments. Consideration of the state-of-the-art suggests that there is a need for new remediation technologies or modification of existing ones; e.g., capping technologies that can sequester sediment contaminants and create a reliable, stable, and long-lasting cap in a range of aquatic environments. Also, the application of in-situ remediation methods such as reactive amendment mats, mixing of amendments in the sediment, and mixing or layering of amendments within sand caps should be emphasized when selecting remedial technologies for contaminated sediments. However, a challenge to all remedial approaches is the continued influx of contaminants from uncontrolled sources following remediation. This can produce a polluted habitat zone that overlies the remediated sediments, thereby negating the benefits accrued by the remedial action. Ultimately, these re-contaminated sediments may once again become a contaminant source. The severity of the problem posed by the influx of contaminants on remediated sediments may be affected by the type of remediation that has been undertaken. Influxes of contaminants on sediments remediated by environmental dredging or by passive capping with inert materials can be expected to degrade the remediated sediments at a rate proportional to the rate of contaminant influx. Remedial effectiveness will be largely negated when sediments become re-contaminated to a depth that encompasses the habitat zone for most benthic organisms. In contrast, the environmental impacts of re-contamination may be reduced if sediments are remediated by chemically active sequestering agents that reduce the bioavailability of inflowing contaminants. A weight-of-evidence approach can maximize the likelihood of incorporating bioavailability measurements into remedial decisions by helping to overcome skepticism by the regulatory community and public. Such an approach will incorporate multiple lines of evidence to address the technical uncertainty associated with individual methods. Although problems remain, contaminated sediment management is improving due to the control and elimination of contaminant sources, development of new remedial technologies, and selection of analytical methods to evaluate metal bioavailability.

Keywords: passive caps; active caps; contaminants, remediated sediment; re-contamination

PL-7

Methylmercury in Seafood: An Information Theoretic Approach

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Seafood is a primary source of both nutrients and methylmercury to human consumers throughout the world. Methylmercury exposure and cycling in marine ecosystems is therefore of considerable importance from both environmental and public health standpoints. In August 2017 the United Nation's Minamata Convention on Mercury entered into force. The primary goal of the Minamata Convention on Mercury is to protect the environment and human health from anthropogenic emissions (air) and releases (water) of mercury. Thus far the role of seafood within the context of the Minamata Convention on Mercury has largely been overlooked. Here I present seafood methylmercury data from throughout the globe to identify the most important drivers and the factors governing the major bioaccumulation regimes of this potent neurotoxicant. Using Bayesian information theoretic approaches and models I evaluate and synthesize methylmercury in seafood across a wide array of spatial and temporal scales. Finally, using these models I evaluate the importance and role of methylmercury in seafood data in the context of the effectiveness evaluation of the United Nation's Minamata Convention on Mercury. The relationships with environmental and public health will also be discussed.

Keywords: methylmercury, seafood, ocean

PL-8

Biochar enhanced electron transfer of zerovalent iron: Importance of biomass

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In this work, pinewood and bamboo were pyrolyzed at 600 °C to prepare PBC and BBC-supported zerovalent iron (ZVI), respectively. Raman spectra suggested PBC was more intensively carbonized than BBC as indicated by higher ID/IG ratio. XRD and TEM confirmed nanoscaled ZVI was well dispersed in PBC but soldered in chain-structure in BBC. Maximal chromate (Cr(VI)) sorption capacity followed the order of PBC/ZVI (5.93 g kg^{-1})>BBC/ZVI (3.61 g kg^{-1})>BBC (3.55 g kg^{-1})>PBC (2.59 g kg^{-1}). Desorption and XPS of four Cr-spent sorbents suggested reduction accounted for 79-88% of overall Cr(VI) detoxification. Greater Cr(VI) reduction of BBC than PBC indicated greater tendency of BBC to donate electrons. However, Cr(VI) reduction by PBC/ZVI was 1.7 times greater than BBC/ZVI, corresponding to greater electron transfer of PBC/ZVI (2.5 μA e^-) than BBC/ZVI (0.5 μA e^-). Thus, PBC is more conducible to transfer electrons as evidenced by Tafel and Amperometric analyses. Demineralization of pristine BC enhanced the difference between PBC/ZVI and BBC/ZVI regarding Cr(VI) reduction, suggesting the dominant role of biopolymers in biomass in terms of electron transfer capacity. Three model biopolymers were compared which indicated lignin-BC had lower electron transfer rates than cellulose-BC and hemicellulose-BC. BC prepared by lignin extracted from pinewood exhibited higher corrosion rate and lower electrical resistance than that from bamboo. Thus, unfavorable lignin in bamboo compromised electron transfer of BBC and Cr(VI) reduction by BBC/ZVI.

Keywords: heavy metals, soil and water remediation, biomass, biochar, zerovalent iron, electron transfer

PL-9

Sustainable Soil Use and Management

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Soil is a key component of Earth's critical zone. It provides essential services for agricultural production, plant growth, animal habitation, biodiversity, carbon sequestration and environmental quality, which are crucial for achieving the United Nations' Sustainable Development Goals (SDGs). However, soil degradation has occurred in many places throughout the world due to factors such as soil pollution, erosion, salinization, and acidification. Moreover, soil pollution by heavy metals and organic pollutants originated from industrial facilities such as coal-fired power plant and E-waste disposal are wide spread, exacerbated by regional scale air pollution and subsequent atmospheric deposition. In order to achieve the SDGs by the target date of 2030, soils must be used and managed in a manner that is more sustainable than is currently practiced. Research in the field of sustainable soil use and management should prioritize the multifunctional value of soil health and address interdisciplinary linkages with major issues such as biodiversity and climate change. As soil is the largest terrestrial carbon pool, as well as a significant contributor of greenhouse gases, much progress can be made toward curtailing the climate crisis by sustainable soil management practices. One identified option is to increase soil organic carbon levels, especially with recalcitrant forms of carbon (e.g., biochar application). In general, soil health is primarily determined by the actions of the farming community. Therefore, information management and knowledge sharing are necessary to improve the sustainable behavior of practitioners and end-users. Scientists and policy makers are important actors in this social learning process, not only to disseminate evidence-based scientific knowledge, but also in generating new knowledge in close collaboration with farmers. While governmental funding for soil data collection has been generally decreasing, newly available 5G telecommunications, big data and machine learning based data collection and analytical tools are maturing. Interdisciplinary studies that incorporate such advances may lead to the formation of innovative sustainable soil use and management strategies that are aimed toward optimizing soil health and achieving the UN's SDGs.

PL-10

Low-Carbon Stabilization of Arsenic and Lead-Contaminated Soil/Sediment

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Arsenic (As) and lead (Pb) contaminated soil/sediment poses an economic and environmental problem worldwide. This study proposes novel approaches for transforming As and Pb contaminated soil/sediment into value-added construction materials by red mud-modified magnesium phosphate cement (MPC) and low-carbon MgO cement with Si-rich waste materials. Experimental results show that the presence of Pb had a marginal effect on the MPC reaction; however, the presence of As suppressed the generation of $MgKPO_4 \cdot 6H_2O$, leading to a significant delay of setting time and a reduction of compressive strength. Extended X-ray absorption fine structure (EXAFS) analysis proved that Pb^{2+} strongly coordinated with the PO_4^{3-}, whereas AsO^{2-} gently coordinated with K^+. The use of red mud enhanced the As immobilisation efficacy to 88.7% due to strong complexation between AsO^{2-} and Fe^{3+}. The treated soils fulfilled requirements of metal(loid) leachability and mechanical strength for on-site reuse. On the other hand, transforming contaminated sediment into value-added construction materials using low- carbon MgO cement with industrial Si-rich minerals is also a sustainable option. Results indicated the potential role of industrial Si-rich minerals in the performance enhancement of MgO-based products via the promotion of magnesium silicate hydrate (M-S-H) gel formation. Pulverised fly ash was found to be a promising Si-rich mineral for generating polymeric M-S-H gel, whereas incinerated sewage sludge ash samples demonstrated a low degree of polymerisation, and the use of glass powder samples gave a low yield of M-S-H. Further experiments demonstrated that Si-modified MgO cement can transform dredged sediment into fill materials with satisfactory mechanical properties and contaminant immobilisation. Therefore, red mud-modified MPC and low-carbon MgO cement with Si-rich waste materials are novel and sustainable options for remediation of contaminated soil/sediment.

Keywords: Green/sustainable remediation; Waste valorization/recycling; Metal immobilisation; Synchrotron analysis; Arsenic/lead leachability.

PL-11

Cycling of Heavy Metals: The Hydrologic Process and Ecological Effect

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Because of the rapid industrialization and urbanization, the contamination of heavy metals has created pervasive environmental and health problem worldwide. The aquatic environment serves as an important sink of heavy metal pollutants, which vary between the particulate, dissolved, and biological phases. The cycling of heavy metals is significantly affected by various hydrologic processes, such as water flow disturbance, benthic bio-disturbance, hydraulic dredging, and other anthropogenic activities. Meanwhile, the hydrologic processes alter the physicochemical factors, like overlying water pH, dissolved oxygen, suspended particulate matter and sediment sulfide and organic matter concentrations, which explain the intrinsic mechanisms of transport and transformation of heavy metals in hydrodynamic environments. The concentration of heavy metals released from sediment under hydrologic disturbances can reach up to 10-fold higher than under natural diffusion. Furthermore, the hydrodynamic conditions can enhance the biological accumulation of heavy metals in various aquatic animals and plants, such as *Corbicula fluminea* and *Vallisneria natans*, which may result in significant ecological consequences in aquatic environments. Nowadays, a growing number of water conservancy projects are under construction, for example, huge dams and reservoirs, which may largely alter hydrologic process and affect the transport and transformation of heavy metals. Therefore, it is necessary to elucidate the knowledge about the environmental processes of heavy metals under hydrodynamic conditions, which plays an important role in future water environment management and heavy metal contaminant remediation.

Keywords: Heavy metals; Hydrologic process; Ecological effect; Water conservancy projects.

PL-12

A Comparative Study of Different Biomaterials for the Removal of Toxic Metal Ions from Water

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Metal ions are notorious environmental pollutants due to their toxicity, persistence in the environment, and tendency to bioaccumulate and biomagnify in the food chain. Robust treatment technologies are required to meet the regulatory limits of different metal ions in the water bodies (e.g. groundwater, surface water, industrial effluents etc.). Among various available technologies, bio-based methods have gained wide interest for the removal and possible recovery of heavy metals from wastewater. In this study, the efficacy of various bio-based materials (e.g. cellulose and biochar) were examined for the removal of different toxic metal ions (e.g. Pb(II), Cd(II) and Cr(VI)) from water. The maximum monolayer adsorption capacity of magnetic wood chips biochar pyrolyzed at 700 ^{0} C (MWC-700) for Cr(VI) was 80.96 mg/g. On the other hand, synthesized cellulose composite showed excellent performance in removing Pb(II) and Cd(II) from water (389 and 115 mg/g) than modified cellulose alone (239 and 92 mg/g). Regeneration studies have confirmed that biomaterials and their composites can be reused for multiple times thus, making the process economically fesible. The results of column-studies have confirmed that biomaterials and composites can be successfully used for practical applications.

Keywords: Biosorption, Metal ions, Biochar, Nano-cellulose.

PL-13

Managing health and environmental effects from contamination of soils with heavy metals and metalloids via mining and agricultural activities

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Historical and current practices of mining and agriculture may result in dispersion of heavy metals and metalloids to the surrounding landscape. Understanding health and environmental effects arising from contamination of soils with heavy metals and metalloids requires the application of risk-based assessments when suitable guidelines are not available. Soil guidelines can indicate heavy metal and metalloid build up in soil or effects on cultivated crops and soil cumulative contaminant loading limit trigger values are generally available for heavy metals and metalloids (kg/ha) for long-term application of dust and water to soil. In addition, heavy metal and metalloid levels in meat from livestock and fowl species are compared against food standard guidelines that take into account all sources of exposure. The air quality guidelines of the World Health Organization (WHO), European Commission (EC) and United States Environmental Protection Agency (USEPA) are based on studies of health effects undertaken globally, and are progressively upgraded. However, little detail exists on effects of air particulates on terrestrial animals. Animals breathe air and may ingest deposited particles on soil surface or via ingestion of grass or other plants. Soil contamination guidelines are well developed for the ecological health case but may require extensive assessment for soil and the native/wild species that are not characterised. The German metal deposition guidelines (TA Luft) are useful in this case, and others that take health and environmental risks into account. In contrast to native/wild species, domestic animal effects from soil contamination and particularly pasture grazing by cattle, sheep, pigs and fowl are well understood. Guidelines for air particulates and fallout may be relevant to assess if deposition is significant to humans or animals but limitations of guidelines for contaminants can still occur. Risk-based assessment for environmental management of spray dispersion of agricultural wastewater and dust deposition to soil can be undertaken so that the significance of contaminants may be assessed if they are dispersed at sufficiently high concentrations. Salinity may also be associated with dispersing trace substances, including heavy metals and metalloids, by spraying mixtures, be important with crop cultivation, and pasture for grazing.

Keywords: heavy metals/ metalloids, dispersion, health and environmental risks

PL-14

Metal(loid) Forms and Biogeochemistry in Mine Wastes

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Mining and processing metal(lid)-rich ore and minerals have generated large amounts of solid wastes (e.g., tailings and acidic-metallic waste rocks) in mined environments worldwide, posing grave contamination risks and hazards to the surrounding natural environments and ecosystem. For example, sulfidic and metallic tailings are rich in metal(loid)s (such as As, Cu, Pb, Zn) which are mostly hosted in minerals, rather than in soluble or organic forms. The mineral-associated metal(loid)s undergo dynamic changes in forms and solubility as regulated by temporal changes of abiotic and biotic conditions, leading to seasonal and abrupt dissolution and release of metal(loid)s, into natural landscapes via seepage and surface runoff. The speciation and mobility of metal(loid)s in mine wastes can be influenced by both geochemical reactions and rhizosphere/microbial processes. Particularly, the forms and surface reactivity of metal(loid)s are closely related to secondary and/or clay minerals (such as Fe bearing phyllosilicates), which are undergoing transformation induced by physcochemical and microbial/rhizosphere processes, leading to the changes of metal(loid) speciation and environmental risks (e.g., bioavailability and toxicity). Understanding biogeochemical processes of metal(loid)s in tailings-plant-microbial continuum would provide the basis for developing effective technologies and methodologies to remediate and rehabilitate tailings and metal(loid) contaminated land at mine sites. This talk will review up-to-date knowledge on the biogeochemical behaviour of metal(loid)s in sulfidic tailings as an example. It also aim to bring up to date emerging technologies about effective immobilization and encapsulation of metal(loid)s of various chemical and mineral forms in mine wastes, for cost-effective and sustainable rehabilitation of mined environments.

Keywords: tailings, metal(loid), mineral capsulation, biogeochemical cycling

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Keynote Lectures

KL-1

A Connection Between Soil Health, Plant Productivity and Quality, and Mine Land Reclamation Success

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Abandoned mine lands are those lands, waters, and surrounding watersheds where extraction, beneficiation, or processing of ores and minerals has occurred. Globally, abandoned mines likely number in the hundreds of thousands to millions. The United States alone is estimated to contain ~ 500,000 abandoned mines. Approximately 33,000 Western US mines generate acidity, leading to increases in heavy metal bioavailability, degradation of mine-affected soils and surface/ground waters, and overall deprivation of environmental quality. Reclaiming affected areas via the use of various techniques has proven successful in the past. However, the intimate connection between reclamation success in terms of plant productivity and quality (and likely improved animal habitation), and soil health (physical, chemical, biological aspects), are gaps sometimes missed during the reclamation process. Typical reclamation of acid generating mine lands include the use of a liming source to raise soil pH, along with organic amendment additions to stimulate microbial activity and nutrient cycling. Several rather unique approaches (e.g., use of biosolids or biochar) to improving environmental quality on abandoned, metal-contaminated US mine lands will be presented, along with our successes and failures in solving these unique environmental challenges.

Keywords: heavy metal contaminated mine lands, soil health, plant productivity

KL-2

Ionic Liquids: A Greener Alternative for Metal Extraction from Aqueous Solutions?

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Ionic liquids (ILs) have been frequently proposed as environmentally friendly alternatives to traditional methods for heavy metal extraction from aqueous solutions. Those compounds, consisting solely of ions, exhibit a large spectrum of unique properties, including high thermal stability, liquid states over a wide temperature range, a very low vapor pressure, varying lipophilicity, or recyclability, some of which are sought-after, environmentally favorable characteristics. The synthesis of task-specific ionic liquids (TSILs) has received increasing interest with regard to metal extraction because ILs can be "tailored" to meet the intended, special properties. Successful metal extraction has been achieved by introducing functional groups in cations as well as anions. These include urea-, thiourea-, or thioether-substituted alkyl groups on the alkyl chains of imidazoles, as well as (thio-)salicylate, maltolate, thioglycolate or hydroxy-naphthoate groups as part of the anion. Liquid-liquid extraction of metals from aqueous phases revealed a major drawback regarding green applicability: partial solution of the ILs during extraction, so-called leaching. Even if TSILs display excellent extraction capabilities, strong leaching can challenge their status as an environmentally friendly alternative, as toxicity of the TSIL often is not known or, if known, it might exceed the toxicity of the metals removed. In our works we recently have synthesized three TSIL, namely trihexyltetradecylphosphonium-, methyltrioctylphosphonium- and methyltrioctylammonium 3-hydroxy-2-naphthoate. They were tested in liquid-liquid extraction experiments for their metal extraction capacities, as well as their leaching behavior; in addition a first estimate of their ecotoxicity was carried out using two freshwater algae in acute toxicity tests as well as the determination of maximum photochemical quantum yield of photosystem II under different TSIL concentrations. Extraction properties of the TSILs tested were excellent, and a quantitative (>99%) removal of metals was achieved under several conditions and from several different matrices including drinking water and water with high salinity. Leaching values were reduced below 1% loss of the applied IL, which can be attributed to the hydrophobic character of 3-hydroxy-2-naphthoate. Acute toxicity assays revealed comparable EC50 (72 h) values of the ILs on both growth and photosynthetic performance for the two algae species. The functional anion 3-hydroxy-2-naphthoate was less toxic than similar compounds; nonetheless, all three compounds must be considered acute toxicants for algae according to the Globally Harmonized System of the Classification and Labelling of Chemicals. Leaching of the ionic liquids into the samples still remains a limitation regarding technical applications due to their ecotoxicity. Further research should therefore focus on IL ecotoxicity and biodegradability on one hand and on the development of environmentally friendly extraction setups on the other.

KL-3

Comparison of Arsenic Accumulation and Speciation in Water Spinach Grown in Flooding versus Upland Soils

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The solubility and mobility of arsenic (As) in the flooding (reduced) soil is higher than those in the upland (oxidized) soil. Water spinach (*Ipomoea aquatica* Forssk.) is a popular vegetable in Asia area, which can be planted in both flooding and upland conditions. Arsenic accumulation (As species) in plants may be different between these two conditions. Therefore, the objective of the present study is to compare As speciation and accumulation in water spinach grown in soils with flooding vs. upland conditions. Soils collected from Guandu (Gd) and Minsyong (Ms) were used, and concentrations of As in Gd soils were 18.4 mg kg^{-1} and 103.3 mg kg^{-1}, and those in Ms were 22.9 mg kg^{-1} and 72.1 mg kg^{-1}. All tested soils were conducted in upland (field capacity) or flooding (3 cm height water maintained above the soil surface) conditions for planting water spinach. The results showed that only inorganic As species were detected in the plant tissues of water spinach, and inorganic As^{III} (iAs^{III}) was the dominant species in root and shoot under upland and flooding treatments. In addition, it was also found that there was significant correlation between the concentrations of iAs^{III} in shoot of water spinach and those in soil pore water ($p<0.001$), and the concentrations of total As and iAs^{III} in shoot grown in flooding condition were higher than those in upland condition. Therefore, the dietary risk of As from consumption of water spinach planted in flooding soil was higher than upland soil. It suggests that in As-elevated soils, water spinach is recommended to be planted in upland condition instead of flooding condition in order to reduce the As intake risk.

Keywords: Vegetable, Water spinach, Water management, Inorganic arsenic, Arsenic.

KL-4

Measuring Biogeochemical Heterogeneity at the Micro-scale in Soils/Sediments: Diffusive Gradients in Thin Films and Planar Optodes

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The activities of organisms and the changes of local conditions can result in significant heterogeneity and geometrically complex reaction patterns in soils and sediments. The observation of soil/sediment heterogeneity strongly depends on the resolution of the measurement method. Therefore, in-situ quantification of the two-dimension (2-D) distributions of pore water solutes at the micro-scale are essential for the investigation of biogeochemical processes. The diffusive gradients in thin films (DGT) technique can be allowed for simultaneous 2-D imaging of sulfides, metallic cations and oxyanions (S, Fe, P, Mn, As, W, V, Co, Ni, Zn, Mo, Sb, Cr, Cu, Pb, Cd and Se) in soils/sediments at submillimeter scale, by combining the high resolution DGT gel and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). In addition, planar optodes (PO) technique can measure the dynamic and distribution of various environment parameters, such as DO, pH, pCO_2 and H_2S in soils/sediments at high spatiotemporal resolution. Until now, we developed the PO and DGT sensors capable of simultaneous 2-D imaging of the above 17 elements and 4 environment parameters, and has been deployed successfully in soils/sediments. As the biogeochemical processes of cations and anions are highly sensitive to these environment parameters, simultaneous 2-D imaging of multi analytes using the combined PO and DGT sensors is a promising method for the study of elements cycling in soils/sediments.

Keywords: Diffusive gradients in thin films, Planar optode, 2-D imaging

KL-5

Insights of Human Health Risks into Soil Management

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Pollution prevention and risk control of soil heavy metal pollution is one of the scientific frontier issues in soil science. The metals-related health risk involving environmental processes, food web transfers and environmental health threats. Human act as the final receptor of metal contamination, acute high-dose and chronic low-dose exposure of Pb, Cd and As, for example, can damage the biochemical properties of liver, kidney, lung and cardiovascular tissues of humans, and even cause cancer. Therefore, measures should be taken to identify the top priority source and sensitive group based on the health risk value to reduce adverse the health effect. Although the several specific components of health risk chain have been investigated (e.g, the spatio-temporal variation, the source apportionment and health risk assessment), a longer chain of the biogeochemical cycle of metals from pollution sources to human health has not been characterized. The limitations prevented us from identifying the impact of source-sink interaction on metals-related health risks and then proposing effective policy decision to soil management. It is suggested that investigating a longer health risk chain of heavy metals to track the critical source and process of metals transportation under different stage (such as primary input, final consumption and body burden) which supports diverse pollution control measures to effectively strengthen soil management.

KL-6

Micronutrient Nutrition in Crop Plants for Better Yield and Combating Malnutrition

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Deficiency of zinc (Zn) and iron (Fe) are widespread and threatening the global food security. Cereals and food legumes are leading staples across the world but inherently low in grain Zn and Fe. Major cereal-based (conventional and conservation rice-wheat cropping systems) and legume-based (chickpea-rice) cropping systems are prone to Zn and Fe deficiency due to intensive cultivation and less use of micronutrients enriched fertilizers. The crop micronutrient deficiency in these cropping systems is also linked with human micronutrients disorder due to consumption of food products derived from these crops (having low concentration of bioavailable Zn and Fe). Over last one decade, we have conducted long-term experiments (laboratory, glass house and field studies) to optimize and evaluate the effect of Zn & Fe (with or without plant growth promoting rhizobacteria (PGPR) (using different application methods) application on the productivity, grain quality and micronutrients (Zn, Fe) bioavailability of rice and wheat (under conventional and conservation systems) and legumes (chickpea and mungbean) on marginal lands. Application of Zn, and Fe significantly increased the concentration of these micronutrients in edible seed fractions of cereals (e.g., endosperm) and cotyledons of legumes with low phytate levels. Moreover, application of these microelements improved grain quality by enhancing grain protein, carbohydrates and amylose contents. It was quite interesting that, effect of Zn application in rice and wheat (under conservation tillage systems) also had residual effect on the following crop with improved grain biofortification and grain quality. Among different application methods, seed treatments were the most economical and cost-effective methods for Zn and Fe application in cereals and legumes. Under the scenario of changing climate, micronutrient deficiencies seem to be accelerated in soils under agricultural crops resulting in low grain yield. Therefore, Zn nutrition under sub-optimal conditions reduce the adversities of abiotic stresses. Moreover, use of seed with high intrinsic Zn proved effective in alleviating the negative impact of abiotic stress in cereals and legumes crop.

Keywords: Cereals; legumes; grain quality; grain biofortification

KL-7

Arsenic as A Global Geogenic Contaminant Affecting Drinking Water Quality and Public Health

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The presence of arsenic (As) as geogenic contaminant in groundwater environment creates barrier to the scaling up of access to safe drinking water, which is a basic human right and poses serious threat on public health through multiple pathways of exposure for the population across the world. The major concern for health impacts result from the occurrence of As in groundwater used for drinking water supplies from direct point sources in rural areas as well as public water supply systems using groundwater sources as raw influent as the source across the world. Despite of a phenomenal deployment of efforts and resources through public and private sectors, several challenges are evident concerning As in rural and urban drinking water supplies while focusing on the developing countries. Drinking water management encompasses an integrated process involves the source water, quality, the treatment systems and its efficiency, the distribution and storage system as well as the consumer system. Treatment of arsenic-contaminated water is an alternative option that can be adopted to make use of available sources, which are likely to be declared abandoned otherwise. Various treatment technologies available for arsenic remediation, including coagulation/precipitation, adsorption processes, membrane filtration, oxidation, bioremediation, and source switching. Arsenic removal using precipitation is a proven and cost-effective method, however, is limited and water quality specific and creates a sludge waste. Removal of arsenic by adsorption is a simple technique without sludge creation. The selection of the most appropriate technology for arsenic removal needs careful pre-evaluation of water quality characteristics, target finished water arsenic concentration, ease of implementation on an existing system, residual management and the cost. Removal of arsenic or any trace metals from water is a challenging task. An existing unsafe source may be substituted by a safe groundwater, rainwater or surface water source; however, various technical, economic and social factors determine the suitability of source substitution in practice. Hence, applying the advanced arsenic treatment options to poor rural settings is generally hindered by the de-centralized nature of the populations. However, basic principles can be shared and therefore many of the conventional technologies can be reduced in scale and conveniently applied at household and small community levels.

Keywords: Arsenic, Removal, Safe water, Treatment, Water Safety Plans, Sustainable Development

KL-8

Streptomyces pactum Act12 Assisted Phytoremediation of Cd and Zn Contaminated Soils by potherb mustard

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Phytoremediation is considered to be an environmentally friendly, non-invasive, energy-saving and cost-effective technology for soil heavy metal pollution remediation. The work of inoculating microorganisms into heavy metal contaminated soil to enhance phytoextraction has attracted extensive attention. This research studied the tolerance and enrichment characteristics of potherb mustard for Cd and Zn, the phytoremediation of Cd- and Zn-contaminated soils enhanced by Act12. The results showed that the germination rate of potherb mustard seed was inhibited by Cd and Zn stresses, which was between 18.3% and 37.8%. The content of Cd and Zn in potherb mustard linearly increased with the increasing Cd and Zn concentrations in growth medium. The highest concentrations of Cd and Zn were 79.9 and 3318 mg kg^{-1} in soil culture, while they were 129 and 5195 mg kg^{-1} in sand culture, respectively. The application of compost decreased the pH value of soil, increased the EC, available P and K, DOC, OM, as well as urease, dehydrogenase and alkaline phosphatase. Act12 combined with Hoagland solution, humic acid and peat significantly increased the contents of chlorophyll and soluble protein in potherb mustard, and thus promoted plant growth, while they were decreased after sulfur treatment. The composition of rhizosphere soil bacterial community had the same trend in the classification of phylum and genus levels. The order of metal extraction amount was Act12 + Hoagland solution > Act12 + peat > control > Act12 + humic acid > Act12 + sulfur. The germination rate of potherb mustard treated with Act12 fermentation broth increased from 37.8% to 50.0%. With the continuous increase of Cd and Zn stress, the germination rate of potherb mustard treated with Act12 broth first increased and then decreased, which increased the resistance of potherb mustard seed to Cd and Zn stress. Overall, it was concluded that Act12 was a potential bioremediation agent for Cd and Zn contaminated soil, and combined application of Act12 and fertilizers could effectively strengthen the remediation of Cd and Zn contaminated soil by potherb mustard.

Keywords: soil, heavy metals, Potherb mustard, phytoextraction, microbial remediation

KL-9

How Heavy Metal Resistant Fungal Communities and Their Interaction with Physicochemical Parameters Influence by Biochar Amendment During Poultry Manure Composting

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This study investigated the influence of coconut shell biochar (CSB) on heavy metal resistance fungi during poultry manure composting by 18S rDNA Internal Transcribed Spacer amplicon sequencing analysis. Five concentration of CSB was amendment including poultry manure add 2.5%, 5%, 7.5%, 10% CSB and without CSB (CK). The sequence number was increased along with the CSB concentration (approximately 41119, 15427, 51142, 72667 and 63725 operational taxonomic units from T1 to T5) and the most abundance of fungi was presented in T4. The phylum of *Basidiomycota* as dominant fungal accounting for 61.14%, 6.16%, 32.18%, 74.65% and 73.73% from T1 to T5 of the total fungi abundance, with widely of the *Wallemiomycetes* and *Eurotiomycetes* classes. Members of the *Wallemia* and *Aspergillus* were the richest genus and species *Wallemia_sebi*, *Altemaria_alternata* and *Aspergillus_amoenus* were detected among all composting. Overall, fungal structure within distinct biochar concentration has similar composition while the relative abundance was varied, richer diverse of fungal community and the superior fungi have been found with the amendment of biochar in composting. Additionally, network correlation patterns confirmed the relative greater percentage of correlation among dominant fungal with bio-available HM and other physicochemical factors increased with the addition of biochar. There was reasonable infer that biochar amendment in composting could be constituted favorable habitat for an active fungal population then contributed to resist heavy metals during organic waste degrading process.

Keywords: Biochar, heavy metal resistance fungal, high-throughput sequencing, composting

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Session 1

SMART biochar technology: A shifting paradigm towards advanced materials and healthcare research

S1-1

Feedstock Type and Production Temperature Interactively Affect Hydrochar Adsorption Capacity for Lead in Aqueous Solutions

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Northern Alberta is well known around the world for its oil sands mining, which generates a large amount of process water. More than one trillion liters of process water is stored in tailings ponds, and without proper management it can pose a threat to both the environment and human health because it contains life threatening contaminants. An example of contaminants in oil sands process-affected water is lead, which has long been classified as an endocrine disruptor and can cause brain disorders in children if ingested or inhaled. By effectively treating the oil sands process water before discharging to the environment, environmental and health impacts can be ameliorated. Effective and economical methods need to be developed to treat oil sands process-affected water or process water produced from other anthropogenic activities. Hydrochar is gaining attention as an adsorbent for environmental remediation due to its large surface area and abundance of oxygen-containing groups, all of which depend on the feedstock type and production condition used for hydrochar production. However, it is unclear if hydrochars can be used to effectively remove contaminants from oil sands process-affected water. Therefore, adsorption and kinetic studies are conducted with hydrochars to determine the efficacy and mechanisms involved with lead removal from aqueous solutions. Twelve hydrochars were produced from four feedstocks (canola straw, manure pellets, sawdust, wheat straw) at three temperatures (180, 240, 300 °C) representing low, medium and high temperatures, respectively, for hydrothermal production of hydrochars. The yield for hydrochar production and the pH and electrical conductivity of the produced hydrochars were determined. Hydrochar surface properties, before and after adsorption, are studied using Fourier transform infra-red spectroscopy, X-ray diffractometry and scanning electron microscopy. Other properties of hydrochars such as specific surface area, elemental composition and ash content are being determined. The pH of the studied hydrochars was from 3.5 to 6.5, electrical conductivity from 0.06 to 0.9 dS m^{-1} and yield from 26 to 72 % (of the quantity of the feedstock used). All three properties were mainly influenced by feedstock type and carbonization temperature, with variations in lignocellulose content of the feedstocks. The pH suggests that hydrochars from canola straw and manure pellet may perform better than those from wheat straw and sawdust as an adsorbent for heavy metals, which will be verified when adsorption and kinetic studies are completed.

Keywords: adsorption, feedstock, heavy metals, hydrochar, hydrothermal conversion, lignocellulose, process water

S1-2

Aqueous Cr(VI) Removal by a Novel Ball Milled Fe^0-biochar Composite: Role of Biochar Electron Transfer Capacity under High Pyrolysis Temperature

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A novel ball milled Fe0-biochar composite was synthesized by ball milling the mixture of biochar (pyrolyzed at 300 °C, 500 °C, and 700 °C) and micron grade iron powder. FTIR, SEM, TEM-EDS, XRD, and XPS were applied to characterize this composite. XRD results showed that iron carbide phase was formed during the ball milling process. The ability of this synthesized composited to remove aqueous Cr(VI) was tested. Removal rates of Cr(VI) (49.6%, 65.8%, and 97.8%, respectively) by ball milled Fe^0-biochar composite consisting of biochar pyrolyzed at 300 °C (300BMFe^0-BC), 500 °C (500BMFe^0-BC), and 700 °C (700BMFe^0-BC) were much higher than those (19%, 11%, and 4%, respectively) by pristine biochar pyrolyzed at 300 °C (300BC), 500 °C (500BC), and 700 °C (700BC). Cr(VI) removal rate by 700BMFe^0-BC increased from 15.4% to 97.8% when prolonging ball milling time from 6 h to 48 h. Ball milling promoted the combination of Fe^0 and biochar as well as reduced the hydrodynamic diameter of the composite. Acidic conditions favored Cr(VI) removal. Ball milling exposed the functional groups of biochar and improved its Cr(VI) removal rate. Raman spectra showed that the degree of graphitization in 700 °C ball milled biochar (700BMBC) was the highest. Electrochemical analysis demonstrated that 700BMBC had the highest electron transfer capacity. In the presence of Fe^0, graphitized structure in 700BMBC acted as an electron conductor, facilitating electron transfer from Fe^0 to Cr(VI). Ball milling also destroyed the surface iron oxide layer to regenerate the composite.

Keywords: Ball milling; Fe^0-biochar composite, Cr(VI), Reduction, Electron conductor

S1-3

Co(II)-Catalyzed Biomass Conversion for Simultaneous Production of 5-Hydroxymethylfurfural Enriched Bio-Oil and Biochar-Stabilized Co Nanoparticles

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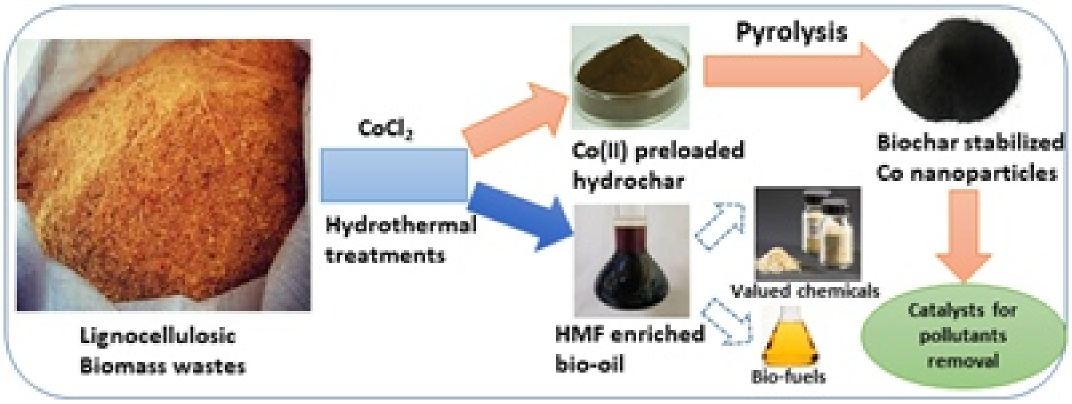
5-Hydroxymethylfurfural (HMF) is an important biomass-derived platform molecule used for producing many commodity chemicals and liquid fuels. We demonstrated a homogeneous $CoCl_2$ system for the catalytic conversion of lignocellulosic biomass into HMF and the simultaneous production of biochar-stabilized Co nanoparticles via a pyrolysis process using the Co(II)-loaded hydrochar generated during the biomass conversion process as a precursor (Scheme 1). The synthesis of biochar-stabilized Co nanoparticles has several advantages over conventional chemical reduction methods. On the one hand, the reduction of Co(II) into Co nanoparticles is achieved by the reducing species (e.g., CO, H_2, and hydrocarbons) formed during the pyrolysis of hydrochar, which avoids the use of toxic and flammable reductants (e.g., NH_2-NH_2 and H2 gas). On the other hand, the reduction of Co(II) into Co nanoparticles (NPs) occurs simultaneously with the formation of biochar, which could facilitate the embedding of the Co NPs on the surface of the biochar, yielding the biochar-stabilized Co NPs. Therefore, in this work, the direct conversion of lignocellulosic biomass into HMF using CoCl2 as the catalyst and the production and subsequent application of the biochar-stabilized Co NPs were systematically investigated. The influence of the reaction conditions on the yields of HMF was explored, and the mechanism for the $CoCl_2$-catalyzed biomass conversion was illustrated. The catalytic performance of the biochar-stabilized Co NPs in the Cr(VI) reduction reaction by formic acid was evaluated.



Scheme 1. Schematic illustration of the strategy for simultaneous production of 5-hydroxymethylfurfural enriched bio-oil and biochar-stabilized Co nanoparticles from lignocellulosic biomass wastes.

Keywords: Biomass, biochar, Co nanoparticles, 5-HMF, Pyrolysis

S1-4

Effects of Ball Milling on the Photochemistry of Biochar: Enrofloxacin Degradation and Possible Mechanisms

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Ball-milled biochar with enhanced physicochemical and sorption properties has been intensively investigated, but its photochemistry is far less studied. In this study, biochars produced at various pyrolysis temperatures were ball-milled and tested to determine enrofloxacin (EFA) photocatalytic degradation and its mechanisms. Ball-milled biochar could generate more $\bullet O_2^-$ under visible light irradiation, which favored the photocatalytic degradation of EFA. The ball-milled biochar pyrolyzed at 300 ℃ (BM300) exhibited the highest EFA degradation rate (80.2% compared with 13.9% for unmilled biochar) and mineralization ability (66.4% compared with 0% for unmilled biochar). The characterization results suggested that more oxygen-containing functional groups played a significant role in the enhancement of photocatalytic performance. Based on the characterization and experiment results, it was supposed that a semiconductor-like structure played a main role in photocatalysis of BM300. A new mechanism suggested that the electrons in carbon defects (as valence band) could be excited by visible light and move to oxygen-containing functional groups (as conduction band), then the electrons in conduction band was further transferred to dissolved oxygen to produce $\bullet O_2^-$, and h^+ could be formed in valence band at the same time. This work applied ball-milled biochar to the field of photocatalysis for the first time, and provided a new opportunity for the removal of EFA in aqueous solutions.

Keywords: Ball milling, Biochar, Photocatalytic degradation, Enrofloxacin

S1-5

Synthesis of Humins-derived Biochar Catalyst from Rice Waste Valorisation for Glucose Isomerisation

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In regard to developing an integrated prototype for the innovative food waste valorisation technology, utilisation of the unavoidable secondary products from biomass conversion to synthesise functional materials was investigated in this study. Under microwave heating at 160°C in $AlCl_3$ solution, the starch in rice waste was effectively converted into value-added chemicals (e.g., HMF) via hydrolysis, isomerisation, and dehydration simultaneously, while forming recalcitrant and insoluble humins as byproduct via condensation of intermediates during catalytic processes. Thermochemical catalytic systems varying substrate concentrations (0.1, 0.15, 0.2 g/mL) and $AlCl_3$ catalyst loading (10 wt% or 20 wt%) in different reaction duration (0-40 min) were tested and compared to determine desired conditions. Subsequently, batch production of humins was conducted in the selected conditions, and the solid residues were collected for carbonisation with/without Al impregnation to produce different humins-derived biochar. The derived solid materials were characterised regarding morphology and structure and evaluated as heterogeneous catalysts for glucose isomerisation under microwave heating at 160 °C, 20 min, yielding up to 14 Cmol% fructose. This research proposed a novel practice for recycling byproduct from waste valorisation to synthesise a renewable and sustainable solid catalyst. Knowledge of the key parameters of conditions and activation to tailor the properties and catalytic activities of synthesised catalysts were presented. This work shows a promising approach for catalyst synthesis from renewable materials, and provide scientific insights to achieve green chemistry and build integrated biorefinery via a closed carbon loop.

Keywords: biomass valorisation, humins, biorefinery, glucose isomerisation, waste recycling

S1-6

Amino Functionalized Invasive Plant Derived Biochar for Sorptive Removal of Hexavalent Chromium in Aqueous Media-Effect of pH

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Hexavalent Chromium (Cr(VI)) and trivalent Chromium (Cr(III)) are the two major stable oxidation states of Chromium (Cr) in the environment. However, Cr(VI) is identified to be more labile and toxic due to its high mobility and released by numerous industries into the environment. Therefore, the removal of prevalent Cr(VI) from all environmental media is pivotal. The objective of this study is to assess the potential of a novel modified biochar produced from a local invasive plant species, *Mimosa pigra* to remove Cr(VI) in aqueous media. *Mimosa pigra*, is mainly found as bushes in the intermediate zone of Sri Lanka. The pristine biochar was produced from *Mimosa pigra* plant species through slow pyrolysis at 350 ℃ within a 2-hour residence time. To achieve improved remediation efficiencies the pristine biochar was modified into amino-functionalized biochar using Hexamethylenediamine (HDA). HDA modified *Mimosa pigra* biochar (HDA-MPBC) was subjected to chemical and physical characterization and compared against its pristine form; *Mimosa pigra* biochar (MPBC). The effect of pH on Cr(VI) removal by HDA-MPBC and MPBC was studied in batch experiments at pH 3-9 with 1 g/L biochar dosage. The remaining concentrations of Cr(VI) and total Cr were measured using UV-Visible spectrophotometer and Microwave Plasma Atomic Emission Spectroscopy (MP-AES) respectively. The biochar yield of MPBC was 35.95%. The proximate analysis of HDA-MPBC, for moisture, mobile matter, ash, and resident matter percentages indicated values of 5.5, 40.8, 5.3, and 48.4 respectively. A higher Cr(VI) removal capacity was observed in the acidic pH values (pH 3 to 4) for both MPBC and HDA-MPBC, whereas removal drastically decreased in basic pH values (pH 7.5 – 9.0). At acidic pH values, HDA-MPBC showed comparatively higher removal percentages than MPBC suggesting the improved sorption efficiencies of amino modification process. Besides, the maximum Cr(VI) adsorption percentage of HDA-MPBC was recorded as 75% at pH 3. At low pH values, residual Cr in the solution was transformed to Cr(III), suggesting the reduction of Cr(VI) to Cr(III) by the biochar. Further research is necessary to understand the effect of time, adsorbent concentrations, and other related mechanisms for the Cr(VI) removal using HDA-MPBC.

Keywords: pyrolysis, *Mimosa pigra*, heavy metals, surface modification

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Heavy Metals in the Environment

Session 2

Metals and human health

S2-1

Environmental and Health Impacts of Heavy Metal(loid)s from Mine Waste through Bioaccessibility and Leaching Studies

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Sulfidic mine waste poses environmental and health risks, especially when the waste also contains high levels of heavy metals and metalloids. In the present study, samples from three sulfidic mine waste sites, originating from closed and active Pb-, Zn-, and/or Cu-mines in Europe, were characterized mineralogically (i.e., XRD) and chemically (i.e., in-vitro bioaccessibility tests and leaching tests analyzed using ICP-OES). An in-vitro bioaccessibility test was performed on the sulfidic mine waste samples and was evaluated in comparison with different leaching tests that are commonly applied to assess the environmental impact of waste materials and sediments. More specifically, the in-vitro bioaccessibility test was based on the simple bioaccessibility extraction test (SBET), which mimics the conditions of the gastrointestinal tract (i.e., pH, viscosity, liquid/solid ratio, and temperature) in two phases to study the behavior of the mine waste particles in the case of ingestion. Additionally, the leaching tests included the US EPA Method 1311 Toxicity Characteristic Leaching Procedure (TCLP), the BCR sequential extraction, and a resuspension experiment on fresh mine waste. The TCLP was intended to determine the toxicity of the waste by simulating the worst-case scenario of co-disposal in municipal landfills. The BCR sequential extraction was performed to determine the trace element fractionation in the samples. A resuspension experiment was used to observe the effects of oxidation of the samples, but at more rapid rate than in the environment. For both the in-vitro bioaccessibility test and leaching tests, the pH was measured and 23 major and trace elements were analyzed, with a particular focus on As, Cd, Pb and Zn. For some samples, SO_4^{2-} was also determined using ion chromatography. The pH and the liquid to solid ratio during the extraction period played a key role in the mobility of the contaminants. PHREEQC geochemical modelling was used to model heavy metal release as observed in the leaching and in-vitro bioaccessibility tests. A health risk assessment was also performed based on the results from the experiments. Given the outcome, potential management scenarios were also evaluated.

Keywords: in-vitro bioaccessibility, leaching tests, environmental assessment, human health

S2-2

Human whole Blood, Fingernails and Hair as Biomarkers of Exposure to Trace Metals Near an Urban/Industrial Mixed Area

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Analytical methods to determine the levels in human whole blood, fingernails and hair of trace metals, which can be considered tracers of the main anthropogenic activities identified in an urban/industrial mixed area of Northern Spain (Santander bay), were developed. According to the literature, these three biological matrices are considered as good candidates of biomarkers of the environmental exposure to trace elements. Some metal(loid)s were selected to represent tracers of anthropogenic activities previously identified in the Santander bay (Hernández-Pellón and Fernández-Olmo, 2019): manganese alloy industry (Mn, Pb and Zn), non-exhaust road traffic (Cu, Fe and Zn) and minor local sources (As). Reference materials for whole blood and human hair (Seronorm™ Trace Elements Whole Blood L-1 and ERM®- DB001) were used to validate the analytical methods to determine the levels of the selected trace elements. The whole blood was diluted in an alkaline solution (1-butanol (20 g/L), EDTA (0.5 g/L), TRITON X-100 (0.5 g/L) and NH_4OH (10 g/L)) and was analyzed by ICP/MS. Hair and fingernails samples were sonicated in a TRITON X-100, 0.5% (w/v) solution, washed five times with ultrapure water, sonicated again in a HNO_3 (1N) solution, washed once with HNO_3 (1N), five times more with ultrapure water and dried overnight at 65°C. After this, samples were microwave-digested with a mixture of 65% HNO_3 and 30% H_2O_2 (ratio 4:1). Later, the samples were filtered, diluted and stored refrigerated at 4°C until further analysis by ICP/MS. The recovery of the certified elements in the whole blood and hair reference materials were between 93% and 110% for whole blood and 93% and 110% for hair. However, the recovery of non-certified elements in human hair reference material was worse, mainly for Mn and Fe. The developed analytical methods were applied to samples collected from a group of volunteers (n=39) living in the Santander bay. This group takes part of an on-going community-based cross-sectional study to assess the potential health effect derived from the environmental exposure to airborne Mn and other metals considered as tracers of the manganese alloy industry. The whole blood concentration of studied elements (μg/L) ranged between 2.11-15.6, 371,596.8-783,651.0, 565.2-1,443.6, 3,336.3-18,395.4, 0.63-32.1, and 1.47-39.1 for Mn, Fe, Cu, Zn, As and Pb respectively. The corresponding values from hair and fingernails samples of these volunteers will also be presented.

Keywords: biomarkers, trace metals, non-ferrous metallurgy, environmental exposure,

Hernández-Pellón, A., Fernández-Olmo, I. (2019). *Sci Total Environ*, *651*, 1476.

S2-3

Co-selective pressure of antibiotic resistance genes and heavy metals pollution in the soil

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The widespread prevalence of antibiotic resistance genes (ARGs) have been identified as an emerging environmental pollutant that is a crucial risk to public health of human beings. There are growing concerns on contribution of heavy metals to the formation of ARGs under the pressure of co-selectivity. Based on geographic information system (GIS) technique, we in this study visualized the relative abundance of 28 kinds of ARGs and concentration of 8 types of heavy metals, and the correlation between distribution of heavy metals and ARGs in the soil of dairy farms in Daqing Duerbert Mongolian Autonomous County, Heilongjiang Province in China. The results demonstrated the significant correlations ($p<0.05$) between heavy metals and the development of ARGs, especially for that between tetracycline and *β-lactam* ARGs (*tet32, tet34, tetAP, tetB, tetC, tetG, tetM, tetO, tetPA, tetR, tetS, tetW, tetX, tetY, tetZ, ampC2, ampC4, blaOXA1, blaOXA10, blaTEM, cfxA*) and four kinds of heavy metals (As, Cu, Ni, Pb, Zn) in the soil. In the soils of different depths, the single-factor pollution index of As was shown to present a heavy-pollution level, which was positively related to the depth of soil profiles. In comparison, Cu, Zn and Cd prefer to be enriched in the surface or sub-surface layer of soil. The pollution distribution of 28 ARGs differed from each other, and their relative abundance normalized to 16S rRNA genes decreased with the increase in soil depth (only except *β-lactam* ARGs). The top three comprehensive score of ARGs ranked the orders of *sul2*> *tetX* >*blaTEM*, indicating the high potential of risk caused by these genes in the soil environment. This study reports a *visual* and deep insight into correlation between distribution of typical heavy metals and ARGs by using GIS technique, which will be of *significance to provide useful information for soil remediation of dairy farm.*

Keywords: Heavy metals; Antibiotic resistance genes; Geographic Information System; Dairy farm

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Session 3

Cycling of heavy metal: The hydrologic process and ecological effect

S3-1

Effects of neutral sewage sludge biochar on Cd enrichment by paddy and greenhouse gas emission in acidic Cd contaminated soil

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Sewage sludge biochar was regarded as a valid approach on contaminated soils remediation to reduce the effect of soil contamination on grains. However, the effect and mechanism of neutral sewage sludge biochar on acidic Cd contaminated soil remediation and green-house gas emission was still unclear. In this study, pots experiments were conducted to investigate the effect of different ratios of sewage sludge biochar to soil on uptake of paddy to Cd in two Cd contaminated rates soil. In parallel, the influence mechanisms of greenhouse gas emissions (CH4, N2O) in biochar remediated soil with Cd contamination were discussed. The results showed that biochar hindered Cd uptake by paddy (the content of Cd in rice decrease 0.15~0.75 mg/kg) by increasing pH and CEC of soil and promoting coordination complexation, precipitation and adsorption of Cd in soil. The increase of soil bacteria and fungi population after using biochar remediation and improvement of soil oxidation and permeability indicated that biochar persistently improved soil fertility, beneficial to the proliferation and development of soil microbes, which lead to nearly zero emission of CH4 and N2O cumulative emission, 10.4~40.6% reduction comparing with Cd contaminated soil without biochar.

Keywords: neutral sludge biochar; cadmium; greenhouse gas; paddy soil

S3-2

Effect of Cadmium bioavailability on its transfer along the terrestrial food chain

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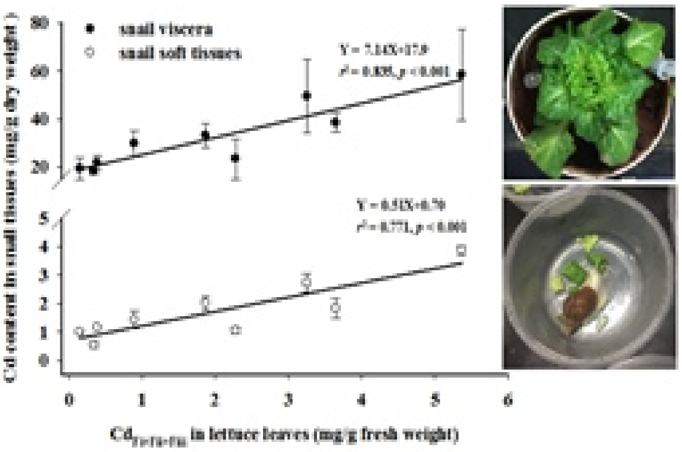
Metal bioavailabilty plays critical roles in the regulation of its environmental behaviors such as phytotoxicity, accumulation and trophic transfer. Distributions of metal in organisms were recognized as the major component of metal bioavailability for decades. Although multiple researches have been proposed to clarify metal such as cadmium (Cd) partitions in plants, how Cd bioavailabilty in preys affect its distributions in predators are still unclear. Recently, we conducted a 60-day pot experiment for lettuce (Lactuca sativa L. var. *ramosa hort*) growth, followed by 15-day snail feeding. Soil bioavailable Cd in rhizospheric pore-water ($Cd_{pore\text{-}water}$) and BCR extraction methods were analyzed, results indicated that soil $Cd_{pore\text{-}water}$ is the best predictor for Cd accumulation in lettuce roots ($r^2 = 0.964$, $p < 0.05$) and leaves ($r^2 = 0.953$, $p < 0.05$), followed by BCR extractable Cd. Analysis of Cd chemical distributions in lettuce tissues showed that Cd mainly presented as F_{iii} form (pectate- and protein-integrated form: 64.8-86.8%) in tissues, followed by the F_{ii} (water-soluble form: 4.55-21.0%) and Fiv (phosphates-integrated form:1.59-15.9%) forms. After 15 days feeding, almost 90% content of Cd accumulated in snail viscera, followed by the soft tissues which accounts for nearly 10%. Linear regression analysis showed that contents of chain transfer associated Cd ($Cd_{Fi+Fii+Fiii}$) in leaves, rather than total Cd, are better correlated with contents of Cd in snail soft tissues ($r^2 = 0.771$, $p < 0.01$) and viscera ($r^2 = 0.835$, $p < 0.001$). Collectively, understanding of Cd bioavailability in various components of terrestrial food chain (soil, plants and animals) could offer more information for consuming food and evaluating the environmental risk of Cd in the ecosystem.



Keywords: Cadmium, soil, lettuce, snail, chemical forms

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Session 4

Management of land affected by diffuse metal contamination: Taking control

S4-1

Assessing Potential Toxic Element Risk of Rock Farming to the Food Chain

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Approximately 7-17 billion tons of rock dusts and quarry by-products are generated annually as a result of mining activities globally. Rock dusts are primarily silicate minerals, but vary considerably in their mineralogical and elemental composition. Rock dusts have found attractive applications in agriculture for removing atmospheric CO_2 via enhanced weathering, meeting crop nutrient demands and improving the quality of degraded soils. Published literature on rock dust application in agriculture have focused mainly on agronomic benefits and CO_2 removal without paying enough attention to plausible unintended environmental effects. One of the most important concerns of rock dust application to soils might be associated with the release of potentially toxic elements (PTEs) in high concentrations during the weathering process. In majority of studies where rock dusts from geological deposit or mountain site were applied to soils, no immediate PTE risk in crops was observed. However, rock dusts obtained from sources like precious metal mines reported critical concentrations of PTEs. This paper presents a comprehensive review of existing literature highlighting the sustainability of rock dust application to cultivated soils from the PTE contamination viewpoint. The specific purpose is to offer a balanced perspective on elemental contents in rock dusts of various origins, and the release of PTEs from the minerals during laboratory leaching, pot-culture and field trial experiments. Potential risk of harmful elements in the food chain following rock dust application to soils is assessed through a critical synthesis of the available data. This paper not only improves the understanding about sustainable application of rock dusts in agriculture, but also helps to develop management strategies to utilize rock dusts for CO_2 removal and soil remineralization in an environmentally safe manner.

Keywords: Enhanced weathering, Negative emission, Potentially toxic elements; Rock dust, Soil remineralization

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S4-2

Baseline Concentrations and Spatial Variability of Cadmium and Lead in Surface Soils in a Selected Agro-climatic Region in Sri Lanka

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The formulation of regulatory standards on maximum allowable concentrations of trace elements in soils is essential for controlling soil pollution. A comprehensive database of background concentrations of trace elements in soils provides a foundation for formulation of practical regulatory limits and helps to identify contaminated soils. Baseline concentration is an alternative to background concentration and estimates the expected range of concentration that 95% of the samples in a randomly selected suite, excluding outliers. This study was conducted to determine baseline concentrations of cadmium and lead in surface soils in a selected region of Sri Lanka, to detect Cd and Pb contaminated areas in the region and to assess the spatial variability of the two elements. Surface (0-15 cm) soil samples were collected at 242 locations covering up- and mid- country regions of the wet zone (Elevation> 300 m, mean annual rainfall>2500 mm, and area= 5054 km^2). Sample locations were identified based on the spatial variability of topography, land use and the geology within the study area. Total concentrations of Cd and Pb in soils showed a log-normal distribution and a majority of samples (95%) had extremely low concentrations of Cd (<0.25 mg/kg) and Pb (0.34 mg/kg) with a few values of higher concentrations. The lower and upper baseline concentrations for soil Cd were 0.04 and 0.34 mg/kg, respectively. They were 5.09 and 45.28 mg/kg for soil Pb, respectively. A few samples (4 for Cd and 2 for Pb) scattered in the region had higher concentrations than the upper baseline concentrations; however, the magnitude that exceeded the upper baseline concentration in those few samples (1.1-3 times) did not indicate an excessive contamination. Spatial distributions of both elements are controlled by the distribution of soil types and followed the same order: Ultisols>Inceptisols>Entisols. The results indicated that the soils in the studied region have not been contaminated with Cd and Pb and their spatial variability is controlled by inherent soil and climatic factors but not by anthropogenic factors (i.e. land use). The baseline concentrations established in this study can be used in developing the regulatory limits to control soil pollution.

S4-3

Long-term behaviour of trace elements in excavated earths naturally contaminated in Molybdenum and Selenium after stabilization

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Published research dealing with diffuse contamination of soils by Trace Elements (TE) have mainly focused on anthropogenic sources. However, many public works operations around the world have revealed that background concentrations could also in some areas represent environmental and economic issues. For instance, the Grand Paris Express Project (GPEP) will generate more than 40 M tons of excavated earths among which a significant amount have been identified as naturally contaminated with Molybdenum (Mo) or Selenium (Se) based on the results from regulatory leaching tests. The leached concentration of these two elements generally exceeds the Inert Waste criteria defined in the Council Decision 2003/33/EC. To avoid extra charges linked with earth's disposal in non-hazardous and non-inert waste landfills, a chemical stabilization process may be efficient and industrially applicable (Geng et al., 2013; Manning and Burau, 1995), even for TE known to be highly mobile in alkaline matrices such as GPEP excavated earths (Rashid et al., 2002). However, current regulations in France have pointed out a lack of guarantees on the long-term efficiency of such treatments (Coussy et al, 2014). The present study investigated the leaching behaviour of naturally contaminated excavated earth samples and the effects of stabilization treatments by mineral amendments. Standardized leaching tests were carried out before stabilization, after stabilization, and after a specific ageing experiment designed to assess the long-term behaviour of TE in the samples. The ageing protocol was based on soxhlet extraction principle (Benzaazoua et al., 2004) consisting in multiplying humectation-desiccation cycles at 70 °C for 10 days in a closed environment. Samples have underwent ageing after and before stabilization. We have shown that Mo and Se concentrations sharply decrease after stabilization in every cases, showing concentrations below Inert Wastes Landfill criteria. On the other hand, variable impacts of ageing have been observed depending on the TE considered. For Mo, best results have been obtained with a zero-valent iron amendment. For Se, all scenarii studied have permitted a retention of at least 90% of total Se or more. The promising results presented here will have to be confirmed by attesting the nature of bonding between stabilizing agent and TE.

Keywords: excavated earths, stabilization, artificial ageing, molybdenum, selenium

S4-4

Application of sustainable drainage system for hydrology and water quality improvement in subtropical regions

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Sustainable drainage system (SuDS) is an ecosystem-based design that has received positive outcomes on both hydrological control and water quality improvement in temperate regions. Whereas, in view of more frequent and extensive rainfall events in subtropical areas such as Hong Kong, the applications of SuDS are encountering regional challenges. To assess the applicability of engineering parameter derived from temperate climates in a subtropical setting, this study evaluated the hydrology performance and water quality improvement of two SuDS (i.e., bioswale and rain garden) at Stonecutters Island Sewage Treatment Works, Hong Kong with synthetic stormwater under different simulated rainfall events (i.e., 2- to 50-year return period). At minor rainfall events, bioswale and rain garden were capable to retain most of the runoff with approximately 70% and 95%, respectively. Regarding the improvement of water quality, moderate removal efficiencies of total nitrogen and total phosphorous were observed. Besides, high removal efficiency was found for most trace elements (e.g., Cd, Ni, Pb, and Zn) except for Cr and Cu, which might due to different removal mechanisms. Nevertheless, larger rainfall events compromised the hydrologic efficiency and pollutant removal by the two SuDS. To increase the treatment capability, biochar can be introduced as the filter media amendment is recommended to generate an anaerobic layer and establish complex root network in the bottom layer of filter media, such that the nutrient capture and pollutants removal could be facilitated. Since the performance of blue-green infrastructures highly depend on the basin area, ratio of treatment area to catchment area, and rainfall intensity, it is suggested to formulate future design of basin sizing criteria based on targeted rainfall events and specific hydrologic objectives.

Keywords: Stormwater, Sustainable drainage system, subtropical climates, heavy metal remediation, Low impact development, Biochar

S4-5

Prediction of potentially toxic elements immobilization efficiency in biochar amended soils: Machine Learning exploration

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In this research, machine learning (ML) was used to develop prediction models for studying potentially toxic elements (PTEs) immobilization in biochar amended soils based on biochar, soil, and PTE properties. The results suggested that random forest (RF) could accurately predict PTE immobilization efficiency of biochar based on the above-mentioned characteristics (training R^2=0.96; test R^2=0.92 and training RMSE =6.55; test RMSE =9.32). A simplified ML model was developed using ML-based feature engineering, and the final importance of each feature to the output target were explored. The results revealed that biochar application rate was the most significant feature on the prediction of PTE immobilization efficiency. The N % in biochar was the second important feature with a positive correlation with PTE immobilization. Consecutively, the soil electrical conductivity and pH were the third and fourth important features, indicating the importance of soil properties in PTE immobilization. However, the surface area of biochar and the pyrolysis temperature were not as important as our expectation on the prediction of PTE immobilization. This study provides new insights for understanding the effect of biochar characteristics, and soil properties for PTE immobilization in contaminated soils.

Keywords: biochar, machine learning, green and sustainable remediation, bioavailability, charcoal

S4-6

Phytomanagement of Trace Element contaminated site by *Malva sylvestris* to produce a natural dye: a plot experiment

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Environmental contamination is a worldwide problem. Europe alone has around 3.6 million contaminated sites. Phytomanagement could provide a solution for large contaminated areas where non-food agricultural practice could still be performed. This can be a sustainable and economic viable option if combined with the valorization of the produced biomass. *Malva sylvestris* (mallow) is a plant species producing a natural colourant that has been previously studied for its potential in phytostabilization on a trace element (TE) contaminated site. The used of this crop species could be an innovative approach in phytomanagement to create a new biobased valorization chain. To assess the interest of *M. sylvestris* for phytomanagement in the north of Europe, an in situ experiment was performed in April 2019 on 3 areas with different contamination levels of a sediment deposit site strongly contaminated by TE such as Zn and Cd. An experiment was set up consisting of 3 areas with 9 plots of 25m² for each area and one plot by area was sowed with the mallow. The aim was to study the effect of mallow on TE soil mobility and assess how the contaminated soil affects biomass growth, final yield and TE accumulation. The results showed a metal tolerance of mallow to a high degree of TE soil contamination (8980 µg of Zn g^{-1} of DS ; 9 µg of Cd g^{-1} of DS) as well that the species was well adapted to the local agro-climatic parameters. The highest concentration of Zn and Cd was observed in the leaves, regardless of the areas (Fig 1). In contrast, the least Zn and Cd concentrations were measured in the flowers which are used to produce dyeHowever, to confirm its potential in phytomanagement, dye extraction to assess TE transfer to the colourant product need to be carried out.

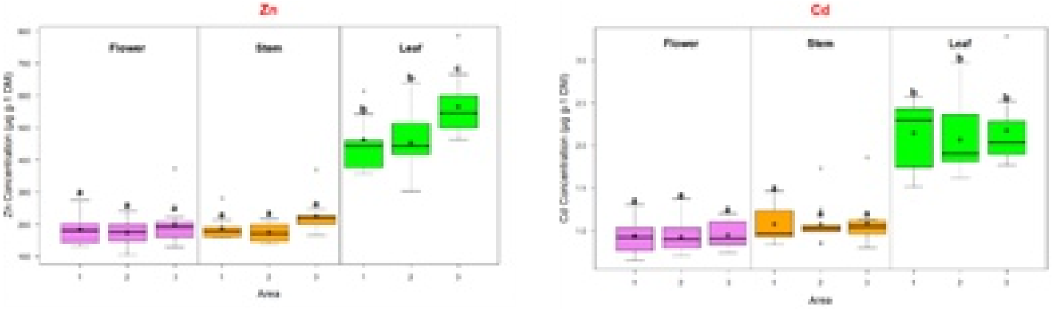

Figure 1. Zn and Cd concentration in plant organs of mallow cultivated in different contaminated areas

Keywords: *Malva sylvestris*, phytomanagement, Cd, Zn, field experiment

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Session 5

Mercury in the environment: Cycling, fate and health risk

S5-1

Mercury Contamination and Microbial Community in Wetland Sediments

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High concentrations of total mercury (max. 60 mg/kg) were found in wetland sediments distributed along the La Plata River, Uruguay. The environmental quality standard for total mercury concentration in soil and sediment pollution in Uruguay has been set at 15 mg/kg, but measured concentrations exceeded this standard value over an area of 15,000 m^2 or more.

This mercury contamination observed in the wetland sediments is caused by industrial wastewater containing mercury (inorganic mercury ions or metallic mercury) discharged from a chlor-alkali factory. Untreated industrial wastewater had been continuously discharged to the wetland since the 1970s, but in the early 2000s, a wastewater treatment plant was installed in the chlor-alkali factory according to UNEP recommendations and government guidance, then the discharge of untreated wastewater was terminated. However, mercury-contaminated zone and hotspots were left in the wetland area, where trace amounts of methylmercury were detected in sediments as well as organisms (reed, shellfish, earthworm, and fish) in the wetland. Microbial community analysis of sediments using the polymerase chain reaction-denaturing gradient gel electrophoresis (PCR-DGGE) method unveiled a presence of bacterial community of the iron-reducing bacterium *Geobacter*, of which biological methylation forms in situ methylmercury. The mercury-contaminated wetland sediments have been affected by the repetition of aerobic and anaerobic environments resulting from repeated lowering and rising river-water levels along La Plata river. Consequently, mercury-contaminated hotspots have been formed with release, leaching, migration, and fixation of mercury. Such hotspots with high levels of mercury contamination pose a significant risk to public health and ecosystems. In order to avoid the risk, detailed mapping of mercury contamination was made, information on the mercury contamination was disclosed to the public and applied a polluter-pays principle for polluting company in taking pollution control measures. The polluting company constructed fences with wire mesh on land and offshore surrounding contaminated zone and hotspots, which interrupted the ecological food-chain and restricted the access by residents.

Keywords: mercury, contamination, wetland, microbial community, *Geobacter*

S5-2

Study on Hg^0 removal performance of carbon-based sorbent derived from coal liquefaction residue raffinate slag

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Coal liquefaction residue (CLR), the main by-product of coal liquefaction, is composed of heavy oil, asphaltene, unreacted coal and liquefaction catalyst. The extraction of CLR will be meaningful for its hierarchically efficient utilization. The remained raffinate slag has the characteristics of high carbon, high sulfur and high ash. It is well known the highly hazardous elemental mercury (Hg^0) has strong sulphophile affinity. Thus, if a kind sorbent with highly efficient Hg^0 removal performance can be prepared from CLR raffinate slag, it may be a suitable and cost-efficient material for Hg^0 capture. In this work, the carbon-based sorbent was prospectively prepared with CH_3COOK as the chemical activator and starch as the binder, and employed for Hg^0 capture from coal-fired flue gas. When the mass ratio of raffinate slag, CH_3COOK and starch was 5:3:1 and the activation temperature was 850 °C, the BET surface area of the sorbent was 235.17 m^2/g and the sulfur content was 2.01%. Under this activation condition, the sorbent exhibited excellent Hg^0 removal performance and the Hg^0 removal efficiency was more than 65% after 8 h adsorption at 150 °C with a gas hourly space velocity (GHSV) of 7.5×10^4 h^{-1}. The sorbent had a wide temperature window for Hg^0 capture of 60-150 °C. Both SO_2 and NO exhibited positive influences on Hg^0 capture, which makes the sorbent more competitive to adapt the complex environment. The XPS and Hg-TPD techniques were employed to explore the Hg^0 removal mechanism, and the results showed that the sulfur in CLR raffinate slag may be the main active site for Hg^0 capture. This study indicated that the CLR raffinate slag is a potential candidate material for preparing efficient sorbent for Hg^0 removal from coal-fired flue gas.

Keywords: carbon-based sorbent, coal liquefaction residue, raffinate slag, elemental mercury removal

S5-3

Evaluation of total cumulative atmospheric deposition of Hg loads with the use of ombrotrophic peatlands as archival records

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The records of cumulative loads of potentially toxic elements (PTE) stored in ombrotrophic peatlands reflect the history of industrial development and pollutant control, as well as relevant temporal PTE emission, long-range transport (LRTP) and spatial deposition. A novel approach to the use of peatlands as precise tools for assessment of total cumulative pollutant atmospheric deposition was illustrated by the assessing retrospective Hg deposition in peat bogs in Norway and NW Poland minor affected by local sources of pollution. The Norwegian peat cores in the deepest layers 100 cm represented the age from 1385 to 3580 years, while Polish peats in the cores 40 cm deep were 655-2060 years old. The uppermost layers up to 7.5-15 cm thick should have integrated Hg deposition following the industrial revolution in Europe, however due to metal release and downward migration with pore solution, its vertical redistribution along the historically pre-industrial parts of cores occurred, with a concentration pattern related to bulk density. While Hg concentrations along the peat cores in the five studied NW Polish bogs sited 30-115 km apart in the area of 130 km in diameter differed substantially, the total accumulated loads appeared to be very similar (mean 3.729±0.598 mg Hg/m^2). In two Norwegian SS peat bogs most affected by LRTP and located 135 km apart, deposited total Hg loads despite 2-fold age difference were practically the same (4.247 and 4.118 mg Hg/m^2), at 83-87% of Hg load accumulated in the layer 0-40 cm and comparable to that in the Polish bogs. In peat bogs located in the central part of Norway of a minor LRTP impact, deposited Hg loads were lesser (2.670±0.110 mg Hg/m^2), i.e. 65-70% of Hg loads deposited in bogs of NW Poland and SS Norway. The lack of larger differences in the spatial distribution of Hg deposition is in conformity with other studies on surface soil and moss, and with EMEP status reports, and possibly related to deposition and surface retention of Hg from the hemispheric pool of Hg^0 of a long residence time in the atmosphere sufficient for a homogeneous mixing over the northern hemisphere. In contrast, almost 2-fold higher Hg deposition in the remote bog in N Norway suggests some not yet well explained sources and pathways of Hg emission and deposition. Overall, the study proved ombrotrophic peat bogs to be precise and reliable tools for evaluation total spatial deposition of fugitive PTEs that can assure the completeness of EMEP data.

The study received partial funding within the Project Contract No. Pol-Nor/199338/45/2013.

Keywords: Hg deposition, Hg total cumulative loads, ombrotropnic peat bogs, load assessment

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Session 6

Risk assessment and remediation of metal contaminated sediments and flooded soils

S6-1

Mechanism of cadmium tolerance and accumulation in submerged macrophytes for contaminated sediment phytoremediation

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Compared with chemical and physical treatment methods, phytoremediation as a cost-effective, eco-friendly, and novel technology has achieved good public acceptance for dealing with heavy metal contaminants. Phytoremediation using submerged macrophytes has been demonstrated to be useful for heavy metal removal from aqueous environments, but little is known about their uses for sediment phytoremediation. In this study, cadmium (Cd) tolerance and accumulation mechanisms of four common submerged macrophytes, including *Hydrilla verticillata*, *Elodea canadensis*, *Potamogeton crispus*, and *Ceratophyllum demersum*, were investigated for restoring Cd-contaminated sediments in aquatic system. Results showed that four submerged macrophytes posed different Cd tolerance. *H. verticillata* and *E. canadensis* had obvious stronger Cd tolerances than other macrophytes, which could tolerate up to 20 mg added Cd (kg sediment)$^{-1}$ in laboratory culture. After harvest, Cd quantification by ICP-OES revealed that *P. crispus* had the strongest Cd accumulation ability with the highest biota-sediment accumulation factor (BSAF, ratio of $[\mathrm{Cd}]_{\mathrm{Plant}}$ to $[\mathrm{Cd}]_{\mathrm{Sediment}}$) in relatively low pollution ($\leq$ 20 mg added Cd (kg sediment)$^{-1}$), followed by *H. verticillata*, *E. canadensis* and *C. demersum*. Because of weak root system, the BSAF of *C. demersum* was less than 1.0, indicating that roots play an important role for phytoremediation of Cd-contaminated sediments. Furthermore, translocation factor (TF, ratio of $[\mathrm{Cd}]_{\mathrm{Aboveground}}$ to $[\mathrm{Cd}]_{\mathrm{Underground}}$) analysis of other three rooted macrophytes showed that *H. verticillata* had the strongest Cd translocation ability, while the Cd accumulation of *P. crispus* was mostly enriched in underground parts. Histochemical studies of macrophyte aboveground parts revealed that most of accumulated Cd was stored in cell walls and protoplasts, together accounting for 53.93-67.82%. Therefore, by uncovering the mechanism of Cd tolerance and accumulation in submerged macrophytes, we could conclude that *H. verticillata* shows the greatest potential for use in Cd-contaminated sediment phytoremediation.

Keywords: submerged macrophytes, cadmium, sediment, tolerance, accumulation

S6-2

Mobility of heavy metals and ecotoxicity of bottom sediment amended with waste materials

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Agricultural and environmental utilization of bottom sediments is one of the most promising alternatives, due to the beneficial properties of sediments rich in clay, organic matter and nutrients. For agricultural purposes, the special attention should be paid to limit the risk caused by the introduction of heavy metals to the soil and then onwards to the food chain. Obviously, the preconditions for agricultural use of the bottom sediments include appropriate content of heavy metals, not causing a harmful and toxic effect to plants. The aim of study was to assess the mobility of heavy metals and ecotoxicological properties of the growing medium prepared on the basis of bottom sediments and different waste (cellulose waste, biomass ash, coffee hulls, and sludge from water treatment). Ecotoxicity of the mixtures was assessed using: Phytotoxkit, Rapidtoxkit, Ostracodtoxkit F and Microtox. The bottom sediments came from the Zesławice Reservoir situated on the Dubnia River in the Lesser Poland Voivodeship. After twenty years of use there has been a significant decrease in capacity (up approx. 40%) due to silting-up. The mixtures were characterized by neutral or alkaline reaction, good sorption properties and low total content of heavy metals. The low share of the mobile fraction (F1) of metals indicated low risk related to metals mobility and potential bioavailability. *Heterocypris incongruens* and *Lepidium sativum* were the most sensitive organism to the substance present in the tested mixtures. Due to valuable chemical properties and low toxicity, the mixtures of bottom sediment and wastes constitute a potentially good substrate for environmental applications in agriculture, horticulture, land reclamation. Only the mixture of bottom sediments and cellulose waste was high ecotoxic, which excludes them from agricultural, horticultural use for consumer crops.

Keywords: growing medium, bottom sediment, heavy metals, mobility, ecotoxicity

Acknowledgements: The study was financed by Higher Education of the Republic of Poland, grant no. 010002-D014.

S6-3

Efficacy and microbial responses of biochar-nanoscale zero-valent ion composite for Cd immobilization in sediments

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Remediation of Cd polluted sediments is crucial for the safety of aquatic environment and human health. In this study, the biochar (BC)-nanoscale zero-valent ion (nZVI) composite (BC/nZVI) was synthesized, and then employed to immobilize Cd in river sediments. The changes of properties, immobilization efficacy, and bacterial communities in sediments were investigated after remediation by different materials, the influences of pH on Cd immobilization were evaluated simultaneously. Results showed that sediment properties were significantly changed by the addition of BC and BC/nZVI. The Cd concentrations in overlying water in treated groups were much lower than the value in control group after 90d-incubation. The overlying water with BC/nZVI addition presented lower Cd compared to raw BC, suggesting that nZVI could enhance the immobilization capacity of BC. The geochemical fraction analysis indicated that the labile Cd (acid-soluble fraction) was partially transformed to the stable Cd (oxidizable or residual fractions) after immobilization. For the influences of pH, the results indicated that the Cd concentrations in overlying water on remedied sediments were generally lower than those in control groups at the same pH values. However, low pH (3 and 5) facilitated Cd release because higher Cd concentrations were observed compared to high pH (7 and 9) treatments, suggesting low pH could reduce the efficacy of BC/nZVI and pose potential negative effects on water quality. Additionally, the BC/nZVI treatments presented better immobilization effectiveness than BC groups at low pH groups due to its alkalescence and high immobilization capacity. The richness and diversity of bacterial communities in sediments were greatly changed after immobilization, and the relative abundance of Fe(III)-reducing bacteria was promoted because of Cd immobilization. Overall, BC/nZVI can effectively immobilize Cd in river sediments, and its effectiveness should be in neutral or alkaline environments.

Keywords: sediment immobilization, Cadmium (Cd), nanoscale zero-valent ion, biochar, bacterial communities

S6-4

Interactive effects of zinc nutritional status and salinity stress on productivity, andioxidative response and grain zinc concentration in wheat

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Salinity is one of the major abiotic stresses, which pose serious threat to wheat production, and is often associated with mineral nutrient deficiencies. Here we studied the effect of salt stress on photosynthesis, biomass production, yield and grain zinc (Zn) concentration of wheat grown under varied zinc (Zn) supply. Two bread wheat cultivars (*Triticum aestivum* L., cvs. Lasani-2008 and Faisalabad-2008) with varied responsiveness to Zn supply were grown in a severely Zn deficient soil supplied with adequate (3.0 mg Zn kg^{-1} soil) or low (0.3 mg Zn kg^{-1} soil) Zn and grown under optimal (no stress) and salt stressed (2500 mg NaCl kg^{-1} soil) conditions. Salt stress reduced instantaneous photosynthesis rate, mineral acquisition and biomass production during the vegetative growth, and low Zn supply exacerbated these effects by salt stress. However, adequate Zn supply reduced the adverse effect of salt stress by increasing leaf chlorophyll and mineral nutrient density (N and K) as well as shoot biomass production. Moreover, adequate Zn supply ameliorated oxidative stress in salt stress plants through enhanced membrane stability, antioxidative response and K/Na ratio in leaves. Plants receiving adequate Zn had higher yield and grain Zn at optimal or salt stressed conditions. Adequate Zn supply also enhanced grain nutritional quality due to increased protein and estimated bioavailable Zn through maintaining a higher endospermic Zn concentration with lower phytate levels.

Keywords: antioxidative response, nutritional quality, photosynthesis, salt stress, zinc

S6-5

Arsenic Contamination in Groundwater along Different Floodplains of Pakistan

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Groundwater arsenic (As) contamination at global scale, especially in South and Southeast Asian countries, including Pakistan represents a potential environmental and public health issue. We undertook groundwater samples along different river floodplains of Pakistan (e.g., River Ravi and River Satluj) and examined the total As and other water quality attributes. The groundwater along River Ravi and River Sutlej flood plains was highly As-contaminated with up to 71% of the wells exceeding As concentration (BDL to 232 µg L^{-1}) above the World Health Organization safe limit (WHO, 10 µg L^{-1}). Notably, As concentration in shallow wells (6.5 µg L^{-1}) was below the WHO limit, providing a safe zone for pumping of groundwater. In contrast, deep wells (41–90 m; As: 55 µg L^{-1} and > 90 m; As: 33 µg L^{-1}) were considered to be unsafe. The hydrogeochemical cycling of As was controlled by saline type of groundwater (Na-SO_4 and Na-Ca-HCO_3) with alkaline pH (pH 7.54 to 9.20), and iron oxides were thought to be major minerals governing As retention/release in aquifers. The elevated As contamination, mainly along Ravi River and River Sutlej flood plains, can possibly be ascribed to reduced water flow in these rivers causing negligible groundwater recharge, and as such triggering As release by oxidation/reduction of iron-rich underground sediments.

Keywords: Arsenic risk; Health; Remediation; Toxic

ICHMET 2020

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Session 7

Interaction of metal (oxyhydroxide) nanoparticles with potential toxic metals: Mechanisms and optimization

S7-

Rapid colorimetric tests for Hg^{2+} and Cd^{2+} ions in water samples with the use of thiol-covered gold nanoparticles

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The release of highly toxic compounds including heavy metal ions necessitates their detection in drinking water and natural water sources. The common approaches for the detection of these ions include atomic absorption- or fluorescence spectrometry, high-performance liquid chromatography etc. Nevertheless, these methods require expensive equipment and complex sample preparation. Colorimetric aggregation analysis is an efficient alternate approach due to simplicity, rapidity, possibility to implement it at out-of-laboratory conditions and estimated the obtained results by naked eye. In this work, gold nanoparticles conjugated with mercaptosuccinic acid (MSA) were used as specific reactants for the detection of Hg^{2+} and Cd^{2+} ions. Metal-induced aggregation of the prepared MSA-capped nanoparticles is accompanied by color change of the colloidal solution from red to blue. Hg^{2+} and Cd^{2+} ions are target analytes that are selectively caused this reaction. In addition to qualitative visual assessment, the aggregation processes may be controlled by a characteristic absorbance ratio, A_{530}/A_{700}. As the result, the proposed system provides detection Cd^{2+} ions with the minimal detectable concentration of 10 ng/mL and the working range 30–110 ng/mL. In the case of Hg^{2+} ions, the minimal detectable concentration was 20 ng/mL and the working range was 30–80 ng/mL. The developed approach was successfully applied to Hg^{2+} and Cd^{2+} ions determination in water for drinking purposes. The proposed technique allows monitoring heavy metal ions in resource-limited settings without complicated synthesis and modification techniques.

Keywords: mercury, cadmium, gold nanoparticles, colorimetry, mercaptosuccinic acid

This work was financially supported by Russian Science Foundation (project # 19-44-02020).

ICHMET 2020
20th International Conference on
Heavy Metals in the Environment

Session 8

Mitigating the global arsenic problem for contributing to meet the 2030 SDGs

S8-1

Assessing the veracity of arsenic mobility in soil amended with biochar

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This study mechanistically addressed the contradiction between the addition of biochar and promotion of arsenic (As) release in soils as employed in the most of previous studies. Three types of biochar containing natural and chemical forms of Si: (i) unmodified rice husk biochar (RHBC), (ii) RHBC modified with Si fertilizer (Si-RHBC), and (iii) RHBC modified with nanoparticles of montmorillonite clay (NM-RHBC) were applied in As-contaminated paddy soil to examine their potential to control the mobility of As in soil-microbe-rice system. Results revealed that both Si-RHBC and NM-RHBC decreased As concentration in porewater by 40-65%, while RHBC decreased by 30-44% compared to biochar unamended soil from tillering to maturing stage. At tillering stage, RHBC, Si-RHBC and NM-RHBC amendments significantly decreased As(III) concentration in the rice rhizosphere by 57, 76 and 73%, respectively compared to the control soil. The overall trend in the immobilization ability of Si-based biochar composites varied in the order of Si-RHBC > NM-RHBC > RHBC suggesting that the form of Si in biochar affects the capability of As immobilization. Results of the quantification of microbial genes revealed that the application of Si-rich biochar amendments can significantly affect the abundance of *16S rRNA* genes and microbial diversity in the rice rhizosphere. The relative abundance of iron reducing bacteria, particularly *Bacillus* and *Geobacter* decreased in soil amended with Si-RHBC and NM-RHBC treatments while minimizing the dissolution of iron oxide minerals associated with paddy soil, thereby decreasing the mobility of As(III). The abundance of the *aioA* gene in soil, amended with Si-RHBC treatment, was twice as much as that of the biochar unamended soil. This suggests that the anaerobic oxidation of As(III) to As(V) on the Si-based ferrihydrite complex tends to be catalysed by *aioA* gene related As oxidizing microbes living in the rice rhizosphere. The immobilization of As is due to: (i) lowering of microbe mediated As release from iron minerals, (ii) oxidation of As(III) to As(V) by aioA gene, and (iii) adsorption on a Si-ferrihydrite complex. The decrease of more toxic As(III) and its oxidation to less mobile As(V) can be introduced as an environmentally viable As detoxification phenomenon in the rice rhizosphere.

Keywords: biochar, silica, rice rhizosphere, immobilization, microbes

S8-2

Modeling Arsenic-Hazard in the Ganges River delta on a regional-scale: India and Bangladesh

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Toxic levels of arsenic in groundwater are found to be widespread across the Ganga-Brahmaputra-Meghna (GBM) River delta, which have led to the large-scale mass pollution among its groundwater-ingesting population. In this study, we have used statistical *[Logistic Regression (LR)]* and machine learning [*Random Forest (RF)* and *Boosted Regression Tree (BRT)]* algorithms to simulate the regional-scale arsenic-hazard (i.e., occurrence of arsenic concentrations above WHO safe limit for drinking water of 10 μg/L) within the in transboundary Ganges River delta, as a function of various geologic, geomorphological, hydro(geo)logic and anthropogenic factors. For this study we have adapted a *'hybrid multi-modeling approach'*, wherein we developed a high-resolution transboundary hydrostratigraphic model for the Ganges River delta aquifer system and subsequently introduced the hydrostratigraphic architectural derivatives (i.e., aquifer connectivity and surficial aquitard thickness) as predictors in simulating arsenic-hazard within the Ganges delta. Our model results unanimously show high arsenic-hazard in the western and north-eastern regions of the delta. The RF model outperforms the BRT and LR model and yields excellent model performance. Of all the predictors used, surficial aquitard thickness and groundwater-fed irrigated area (%) shows the strongest association with As-hazard within the delta. Block-level estimation revealed that ~30.3 million people are exposed to high As-hazard zones within the delta. Such models can also be very helpful in delineating arsenic-hazard zones in other areas across the globe having a similar geologic setting with limited groundwater arsenic data.

Keywords: Ganges River, Arsenic hazard, Hydrostratigraphy, Machine learning

S8-3

Using geospatial methods to monitor arsenic variability in gold mining areas of northern Tanzania

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Groundwater contamination by arsenic (As) is one of the environmental problems impairing access to safe drinking water in many parts of the world. In Tanzania, arsenic has been sporadically reported within the gold mining areas south and eastern parts of Lake Victoria in north-western Tanzania. The aim of this study was to investigate the influence of mining activities to the As concentrations in groundwater using geospatial methods. A total of 130 water samples were collected from groundwater-based drinking water sources in 13 administrative wards following a pre-defined protocol developed in accordance with previous scientific studies focusing on As pollution. Groundwater was sampled using a 1-L polyethylene bottles from dug wells, shallow wells, boreholes, and springs. When sampling hand-pumped wells, water was left to flow for some time before sampling as a means of getting representative water samples from the aquifer. The Hach Arsenic Field Test Kit was used to quantify the trace amounts of total inorganic As concentrations in the range of 10-500 ppb directly on site thereby giving a first indication of the contamination in groundwater-based drinking water sources. The location for every sampling point was determined using hand-held global navigation systems (Global Mapper 20 Series, ±3 m accuracy). A positive global Moran's I statistic indicating clustering in arsenic concentrations was obtained. The influence of mining activities was studied based on 250 m prediction grids that were generated by ordinary kriging method. The variation of predicted arsenic concentrations was monitored by classification grid points at every 0.1 km with mining site boundary as a reference. Plot of geometric mean As concentrations against distance revealed increasing trend with increasing distance from the mining sites up to 7.6 km. Beyond this distance, cyclic variations were observed implying the influence of small scale mining and other human activities which need further investigation to ensure drinking water safety for the rural population of Tanzania.

Keywords: Groundwater contamination, Arsenic, geospatial analysis, Gold Fields, Tanzania

ICHMET 2020
20th International Conference on
Heavy Metals in the Environment

Session 9

Metals in the circular economy: Novel, sustainable technologies for metal recovery from low-grade ores and wastes

S9-1

Selective Copper Recovery from Ammoniacal Waste Streams Using a Systematic Biosorption Process

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Liquid waste streams containing Cu and NH_3 present an important secondary Cu resource that could bring economic benefits and sustainability. Conventional recovery methods for this type of waste are generally costly, environmentally damaging, and non-selective towards Cu. Thus, we propose the use of a systematic biosorption process as an efficient and selective approach to remove and recover Cu in the presence of NH_3. Five biosorbents with different properties—pine cone (PC), brown macroalgae *Fucus spiralis* (FS), chitosan (CT), sewage sludge biochar (SSBC), and lignin-rich digested stillage (LRD)—were selected from a set of low-cost materials screened for the adsorption of Cu from NH3 solutions. The effects of different process parameters on the adsorption of Cu onto the five biosorbents were investigated. Biosorbent surface characterizations and chemical speciation modelling were also performed to understand the Cu adsorption trends better. The most favorable Cu removal was observed at pH 11 for all biosorbents, except PC, which worked efficiently in a wider pH range. The *qmax* (mmol/g) of the biosorbents for Cu in the presence of 2 M NH_3 at pH 11 follow the order: CT (1.56) > PC (0.94) > FS (0.91) > LRD (0.87) > SSBC500 (0.30). All biosorbents showed selectivity for Cu over Zn. Furthermore, the presence of 5 mM Zn increased the *qmax* of PC and FS to about 1.10 mmol/g. When used in a real leachate containing 6 mM Cu(II), 1.1 mM Zn(II), 1 M NH_3, and 0.5 M CO_3^{2-}, PC still achieved a relatively high Cu removal efficiency of about 70 %. All gathered information were coupled with chemical speciation modelling and surface characterizations to determine the parameters and biosorbent properties contributing to a selective Cu biosorption process.

The results of this study suggest that biosorbents screening, chemical speciation modelling, and biosorbent surface characterization can be used as effective tools in finding a biosorbent that could work for a particular waste stream. This approach should be further tested on other secondary metal resources for validation. For this purpose, a high-throughput automated platform will be used to perform the adsorption experiments for different waste streams in a shorter period of time.

Keywords: biosorption, Cu-NH_3 complexes, metal recovery, selectivity, speciation

S9-2

Bio-metallurgical process for extraction and recovery of lead from low-grade mineral tailings of zinc refining

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Lead (Pb) is an important by-product during zinc extraction and refining from *franklinite* ($ZnFe_2O_4$) and *jarosite* ($KFe_3(SO_4)_2(OH)_6$) minerals. It is persistent during hydrometallurgical extraction using concentrated sulfuric acid and resides in a *gypsum* ($CaSO_4 \cdot 2\ H_2O$) tailing which has unfavourable properties for pyro-metallurgical treatment. Currently, the contaminated residue is stored on land, despite its relatively high metal content. Valorisation of the residual metal content and bulk gypsum matrix in *e.g.* construction material, is envisioned during the proposed bio-metallurgical extraction and recovery process. Heterotrophic bioleaching is done through the production of organic lixiviants by microorganisms, *Aspergillus niger* in this case, in the presence of and external energy and carbon source. Due to their low-carbon impact and operation at ambient temperature, bio-metallurgical extraction techniques have distinct advantages over traditional refining processes. Complete Pb extraction from the mineral tailings is achieved upon optimal bioleaching conditions. A design of experiments in which the concentration of citrate as lixiviant, the solution's pH and incubation time were varied, resulted in a Pb concentration of 15 g/L in the pregnant leachate. Full depletion of the substrate was confirmed by SEM-EDX measurements. Finally, an electrochemical system of two-compartments that operated potentiostatically at 3.00 V, was used to induce lead precipitation in the metal-bearing anolyte, whilst ensuring alkaline conditions for consecutive bioleaching at the cathode compartment. Characterization of the recovered lead precipitate by ICP-OES analysis, PXRD and Raman spectroscopy indicated for an amorphous, white residue containing 25 m% Pb.

Keywords: Bioleaching, Environmental clean-up, Lead extraction, Metal recovery

S9-3

Production of a mixed rare earth elements compound using the ashes of the hyperaccumulator *D. linearis*

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The production of rare earth elements (REEs) from ion-adsorption deposits in South China, which constitutes an important part of the global production, is becoming more and more prominent. To reduce its environmental impacts, there is a growing research effort on the recovery of valuable and strategic elements from secondary sources. The fern *Dicranopteris linearis (*syn. *dichotoma)* has been identified as a REEs hyperaccumulator and aluminum (Al) hyperaccumulator growing on the acidic soils over the ionic adsorption deposits. Its biomass (fronds) is considered as an alternative source of REEs. Its superior Al content makes the recovery challenging, as the latter is known to cause separation problems. The fronds of *D. linearis* collected on a former mine in Dingnan, Jiangxi Province (China) were ashed at 550 °C during 3 h. The ash was enriched through an alkaline leaching step with NaOH (6 M) in order to selectively dissolve silicon and aluminum. After rinsing the solid with water, selective dissolution of the REEs was conducted in diluted HNO_3 at regulated pH 4.5 in a series of sequential batches at ambient temperature. Pregnant solutions were collected and REEs carbonates were precipitated using NH_4HCO_3. Crystals were aged 6 h at 40 °C. ICP-AES analysis revealed that the ashes contained 23 wt % Si, 6 wt % Al and 3 wt % REEs. Alkaline leaching proved to enrich the ash: REEs were concentrated from 3 to 14 wt %, while 90 % of the initial aluminum content was removed. Recovery yield of the REEs in aqueous solution at pH 4.5 was very good, while precipitates showed high purity. This work proved the feasibility of REEs recovery from *Dicranopteris linearis* ashes. Aluminum separation conducted along the process proved to be relevant by preventing unwanted co-precipitation in the last stage. The process will be subject to economic analysis and impact assessment before further scale-up.

Keywords: Agromining, *Dicranopteris linearis*, Rare earth elements, Hyperaccumulator plant

S9-4

Agromining of nickel

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Agromining is a process whose objective is to extract a metal from the soil using hyper-accumulator plants and to use hydrometallurgy to recover the metal contained in the biomass of the plants. This approach has been widely developed for nickel (Ni), since this metal is naturally contained in serpentine soils in many regions of the world, and approximately 500 Ni-hyperaccumulator plant species have been identified. In recent years, and particularly in the framework of the European “Life Agromine” project, we have studied the agronomy of these plants and their large-scale cultivation, and developed processes from the laboratory to the pilot scale, to produce nickel-based compounds and recover energy from plant combustion. The environmental impact of the chain has also been assessed through life cycle assessment. The following is a summary of the knowledge gained, particularly on the process aspect, which involves the subsequent steps: the dry plant is burnt to produce ash, which is a true bio-ore containing between 10 and 20 wt % Ni; the ash is washed to extract the potassium and then leached with acid to transfer the Ni into solution. The solution is then treated to precipitate nickel-based compounds (various options are available, including oxide or salts). In the Life project, combustion and energy recovery (at the scale of a boiler) were studied in detail, as well as the production of different compounds from different plants of the *Brassicaceae* family, the reuse of effluents and by-products was also considered. All of this information made it possible to demonstrate the industrial interest of the sector. Ni agromining is now being extended to the recovery of other plants, from tropical regions, growing on mining soils and tailings. This approach is also being developed for other elements and metals of interest, such as rare earths.

Keywords: phytoextraction; hyperaccumulator plants; hydrometallurgy; circular economy

S9-5

Biotechnological strategies for the recovery of technology critical elements from electronic wastes

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Technology critical elements (TCEs) (i.e., platinum group elements (PGEs), rare earth elements (REEs), Nb, Ta, Ga, Ge, In, Tl, Te) as well as some base and precious metals are essential in the development of novel high-tech applications. They are essential in green technologies, including renewable energy, emission free electric vehicles and energy-efficient lighting. However, the sustainable supply of TCEs and some other elements is a major concern. Waste electrical and electronic equipment (WEEE) is recognized as an important secondary source of TCEs. There are several options to recover TCEs and precious metals from these waste streams, and biotechnologies have been seen as a promising alternative to the current industrial best available technologies (i.e., pyrometallurgy). These technologies encompass biologically induced leaching (bioleaching) from various matrices, biomass-induced sorption (biosorption), and bioelectrochemical systems. The current frontiers in critical raw materials (CRMs) recovery from WEEE using biotechnology, the biochemical fundamentals of these bio-based technologies the recent research and development activities will be presented.

Keywords: Bioleaching, Biosorption, Bioprecipitation, Critical metals, Electronic waste

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Session 10

Metals-microbe interactions

S10-1

Physiologically based pharmacokinetic model for the biotransportation of arsenic in marine medaka (*Oryzias melastigma*)

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The toxicity of arsenic (As) targets specific tissues of organisms, while the biotransportation of As among the tissues of fish remains poorly understood. In the present study, radiotracer techniques followed by a physiologically based pharmacokinetic (PBPK) modeling were applied to simulate the biotransportation (absorption, distribution, and elimination) of 73As(V) and biotransformation of As(V) in the marine medaka Oryzias melastigma after waterborne As exposure. Fish were simulated by a six-compartment model by assuming that blood was the intermediate exchange among different compartments (gill, intestine, liver, head, and carcass). Modeling suggested that intestine and gill were the uptake, exchange, as well as elimination sites of waterborne As, while carcass and head were the main storage sites. Intestine played a vital role in the metabolism of As(V) by biotransforming inorganic As into arsenobetaine (AsB), possibly because of the important role of gut microbiota. The correlation between the PBPK model constants and the As speciation (e.g., AsB %, inorganic As %, and methylated As %) indicated that AsB tended to be stored in the tissues rather than being depurated, while inorganic and methylated As were more easily transferred from tissues to the blood and eliminated. Modeling simulation coupling with biotransformation for the first time demonstrated that the fish intestine was the main metabolic site, and synthesis of AsB as mediated by the microbiota in the intestine contributed to the high As bioaccumulation in marine fish.

Keywords: Arsenic; Biotransportation; Biotransformation; Physiologically based pharmacokinetic (PBPK) model; Marine fish

S10-2

Effects of Cd, Cu, Zn and their interactions on microbial biomassand bacterial community structure in field and laboratory experiments

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Soil physicochemical properties (e.g. soil organic matter, moisture, pH, soil type, etc.) not only influence the toxicity of heavy metals, but also contribute to differences in microbial community structure. Therefore, it is important to evaluate the long-term and short-term effects of heavy metals on microbial biomass and the microbial community in soils of similar physicochemical properties. Our aims were to simultaneously compare the effects of Cd, Cu, Zn and their combined action on microbial biomass and bacterial community structure, both in a long term Chinese field trials and short-term laboratory experiments on the same soils. Our hypothesis was that there are comparable relationships between the effects of heavy metals measured in the environment and in the laboratory, so that laboratory results can be used as valid predictors of the environmental effects of heavy metals in soil. Despite the low Cd concentrations in the field soil (maximum metal concentrations 300 Zn, 500 Cu, 1.5 mg Cd kg-1 soil), Cd apparently produced the most significant negative correlation with biomass C. However, in the laboratory experiment (250, 400 and 1.5 mg kg-1) there were no decreases in biomass C or ATP, or changes in microbial community structure at lower metal concentrations and only at the high Cd +Zn and Cd + Zn + Cu concentrations. At the heavy metal concentrations applied in the laboratory experiment, the effects of Cu on the microbial biomass and bacterial community were greater than Cd and Zn. Although Cd had no significant effect on the microbial biomass below 1.5 mg kg-1, the synergistic effect between Cd and Cu made a significant difference to the bacterial community. There was also a competitive relationship between Cd and Zn. Therefore, should heavy metal standards be applied in the future based on their effects on soil microbes, these results suggest that it is important that the combined toxicity of heavy metals should be considered, rather than the activities of individual metals. Based on this study, we also conclude that there is little or no relationship between field and comparable laboratory experiments on the effects of heavy metals on microbial processes. Also, determining the effects of individual heavy metals on the microbial community under field conditions is likely to give false conclusions when other metals are also present.

Keywords: Cd, Cu, Zn, long-term and short-term pollution, microbial community

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Session 11

General Session

S11-1

Gasification biochar from biowaste (food waste and wood waste) for effective removal of radioactive 137-Cs and 90-Sr in aqueous solutions

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A lot of radioactive wastes (i.e. liquid, concrete, and soil) containing cesium, strontium, and tritium are generated in decommissioning of nuclear power plants. The effective materials and treatment are necessary to decrease the amount of radioactive waste for the reduction of decommissioning cost. Biochar is newly proposed as an innovative and cost-effective adsorbent for various pollutants such as toxic metals and PPCP. For the screening test, the cesium adsorption was examined using 12 standard biochars prepared by six different raw materials (i.e., sewage sludge, wheat straw, soft wood, rice husk, oil seed rape straw, miscanthus straw) at two different pyrosis temperature conditions (i.e., 550 and 700°C). The radioactive cesium adsorption was conducted at room temperature of 25°C in solution. The adsorption capabilities of biochar declined with the increase of pyrosis temperatures at 700°C, because high temperature destroyed surface functionalities with the rise ash components in the biochar. Therefore, the sorption processes of biochar for radioactive cesium were predominantly controlled by final production temperature of biochar. Biochar was produced from feedstock mixtures of food waste and wood waste (i.e. 30% chicken manure:70% wood WCM, 40% food waste:60% wood WFW) by gasification. The biochar adsorbents of WFW were activated by KOH (i.e. WFWK). The radioactive ^{137}cesium and ^{90}strontium adsorption were conducted at room temperature of 25°C in solution. The adsorption result showed that WFWK was highest efficiency for ^{137}cesium and ^{90}strontium removal at pH 1 and 8 in aqueous solution. More than 80% of the radioactive ^{137}cesium ions were removed from solution, even in presence of competing ions, such as Na^{+} (100 ppm). These results indicated that the development of micropores by KOH activation significantly increased the ^{137}cesium and ^{90}strontium removal. Various analytical tools were used to identify the adsorption mechanism using XRD, FT-IR, and synchrotron-based investigations (EXAFS). The Cs K-edge EXAFS spectra revealed that the only single coordination shell was assigned to the Cs-O bonding at 3.11 A, which corresponds to outer-sphere complex between ^{137}cesium and biochar. The gasification biochar derived from biowaste (food waste and wood waste) could be effective adsorbents for radioactive ^{137}cesium and ^{90}strontium in aqueous solutions.

Keywords: Biochar, Gasification, radioactive, Cesium, Strontium, decommissioning

S11-2

Application of S-impregnated biochar on methylmercury removal in water and sediment

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Biochar (BC) are carbonaceous materials that are prepared by incinerating biomass under oxygen-deprived conditions. Previous studies have shown that BCs have high sorption capacity for heavy metals and their organic derivatives. Modifying biochar through physical and chemical processes can significantly alter its performance as sorbent for metal contaminants in aquatic environment. In this study, pine needle biochar was impregnated with S via post-pyrolysis S stream exposure at different loading ratios of 1-20%. The prepared sulfur-modified biochar (BCS) were tested for its mechanism for removal of MeHg in water and in sediment. Elemental analysis, raman spectroscopy, Fourier transform infrared spectroscopy and X-ray photoelectron spectroscopy (XPS) confirmed adulteration of S functional groups on the surface of the BCS. The removal performance of BCS for methylmercury (MeHg) in water decreases with increasing %S loading due to increased blockage of pores as confirmed by BET surface area analysis and scanning electron microscopy. The sorption process for the BCS is best described by the Freundlich isotherm with highest observed K_F of 5.91 mg L g^{-1} for 1% BCS (BCS1). The kinetics of sorption follows a pseudo second-order adsorption with BCS1 showing a rate of 0.36 g mg^{-1} hr^{-1}. XPS analysis showed that the mechanism of sorption for MeHg by the BC occurs through formation of complexes between Hg and the O and S functional groups present in the SBC. With increasing %S loading, the sorption process shifts from Hg-O to Hg-S bonding. Addition of BCS to Hg-contaminated sediment in anoxic condition lead to the reduction of both total mercury (THg) and MeHg levels in pore water. The reduction in the bioavailable fractions of Hg resulted to reduced mercury methylation in anoxic sediment.

Keywords: biochar; methylmercury, sulfur impregnation, sediment amendment

S11-3

Diverse utilizations of biomass biochar over thermochemical processes

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An increasing biomass waste can be processed over thermochemical processes such as gasification and pyrolysis to produce producer gas, liquid fuel, and biochar. Although many studies on the biomass waste product utilizations were performed, there are still rooms for making complete commercialization process for its final product. Especially, biochar has high potential for different applications; VOC or CO_2 adsorption material, catalysts for pyrolysis oil upgrades or methane gas production, and electrochemical material. The biochar properties can be determined based on three major production conditions; 1) compositional properties biomass waste, 2) waste process type and its operating conditions, and 3) post-treatment of biomass products. These major conditions for the utilization of biochar is typically considered based on many factors such as the production rate, the production cost, the process difficulties, the product quality, and its final applications. In this presentation, the biochar production conditions will be discussed by relating to the properties of its biochar and its right applications, based on different biochar studies.

Keywords: Thermochemical conversion, Biomass waste, CO_2 sorption material, Supercapacitor, Catalyst

S11-4

Particle Size Distribution and Enrichment of Metal Components in Fly Ash from Oxy-fuel Combustion of Waste Sludge

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Comparative tests in air and oxy-fuel combustion with oxygen injection rates ranging from 21% to 40% were conducted in a 30kWth circulating fluidized bed (CFB) pilot plant for waste sludge combustion. General combustion characteristics of the CFB such as pressure profiles, temperatures along the bed, and flue-gas composition, were different under the air and oxy-fuel conditions with various oxygen injection rates. Based on the results, the optimal oxygen injection rate was determined as 25% for the oxy-fuel combustion. In the bottom and fly ash, alkali and heavy metals had different distribution under the air and oxy-fuel combustion conditions. The particle size distribution in fly ash from air combustion was dominated by coarse particles over 2.5μm in size, whereas with oxy-fuel combustion, most particles were submicron in size approximately 0.1μm, and a smaller amount of coarse particles over 2.5μm in size formed than with air combustion. Mass fractions of Al, Ca, and K below 2.5μm in size found in the ashes from oxy-fuel combustion were higher than those in air combustion were. Submicron particle formation from the Cr, Ni, Cu, and Zn in the fly ash occurred more during oxy-fuel combustion than it did in air combustion.

Acknowledgement: This work is supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) and the Ministry of Trade, Industry & Energy (MOTIE) of the Republic of Korea (No. 20184030202240).

S11-5

An Investigation on Adsorption Behavior of Radioiodine on Hydrotalcite-like Clay Mineral using Extended X-ray Absorption Fine Structure

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Hydrotalcite has known as anionic clay, which is containing divalent and trivalent metals with interlayer anions. It is newly proposed as an innovative and cost-effective material for the anionic contaminant. In this study, hydrotalcite was artificially synthesized by the coprecipitation method for the investigation of iodine adsorption. To examine adsorption behavior of the iodine species on the hydrotalcite, batch adsorption experiments, and I K-edge Extended X-ray absorption spectroscopy (EXAFS) studies were carried out. The results show that calcination of hydrotalcite enhanced the adsorption capacity by rehydration process, whereas there was no remarkable difference by increasing magnesium ratio in hydrotalcite. The Fourier Transform spectra of iodide corresponds to a single shell at 2.80Å. This single shell corresponds to the I-O single bonding of hydrotalcite, which suggests the presence of oxygen neighbours only from water molecules and hydroxide in the interlayer. Otherwise, iodate showed single I-O bonding at 1.81 Å, which demonstrates typical outer-sphere complex between hydrotaclite and iodate species. These results explain the adsorption behavior of iodine on the surface of hydrotalcite-like clay mineral.

S11-6

Effective decontamination strategy of radioactive soil: Removal of Cs using soil washing assisted by magnetic separation process

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A large amount of radioactive Cs has released to the environment during the nuclear accidents such as Chernobyl and Fukushima, and contaminated the surrounding soil in a wide area. Although considerable decontamination progress has been attempted in the remediation of radioactive soil, it is difficult to remove Cs from the contaminated soil due to the strong affinity of Cs with clay minerals in the soil. In this study, we evaluated the decontamination efficiency of ^{137}Cs-contaminated soil using a combined process of soil washing and magnetic separation methods. First, the clay- and silt-sized fine particles were dispersed from the soil aggregate using ultra-sonication under alkaline conditions. Second, the negatively charged fine particles were selectively separated from the soil using cationic polymer-functionalized Fe_3O_4 nanoparticles under magnetic fields. Finally, the remaining soil (i.e., sand-sized particles with a poor Cs^+ concentration) was treated by desorbing Cs^+ from the soil using oxalic acid under hydrothermal conditions. The results showed that high reduction of waste volume and radioactivity of the contaminated soil was achieved by the proposed decontamination processes. Therefore, the decontamination strategy can be a practical technique for the remediation of radioactive contaminated soil.

S11-7

Surface modification of polymeric support materials for immobilization of nano-sized adsorbent for toxic heavy metals

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Heavy metal pollution is one of the major concerns in water management. Several types of nano-sized adsorbents have been reported as effective materials for heavy metal adsorption. However, the small size of the adsorbent makes it difficult to recover after being disposed in the water system. In this study, we tried to immobilize the nano-sized adsorbent on polymeric supporting materials in order to facilitate the practical application. The nano-sized adsorbents considered in this study were the Prussian blue for radioactive cesium and the disulfide organic polymer for cadmium. The surface functionalization of polymeric support materials using acrylic acid was performed to graft the carboxyl groups on the polymer surface, which help to improve the immobilization stability of the adsorbents. As a result of surface functionalization, more adsorbents could be immobilized on the polymer surface; consequently, enhanced heavy metal removal could be achieved. Specifically, the cadmium adsorption capacity was increased more than four times by attaching the disulfide organic polymer on the surface of PP/PE filter, and the Prussian blue immobilized cellulose filter could adsorb 16.7 mg/g of cesium. The developed surface modification process is a versatile and straightforward method to enhance the overall filtration performance of commercially available polymeric filter media.

Keywords: nano-sized adsorbent, cadmium, cesium, surface functionalization, acrylic acid

Acknowledgment: This work is supported by a National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP; Ministry of Science, ICT, & Future Planning) (No. NRF-2020R1C1C1003428), and by the Creative Convergence Research Project (CAP-15-07-KICT) of the National Research Council of Science and Technology (NST).

S11-8

Alkali Metals Corrosions on Boiler Tube in Waste to Energy Facility

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Typically, municipal solid waste contains large portion of combustible matter to recover heat energy by thermal treatment. Conventional combustion is promising and well-known technology to treat municipal solid waste safely. However, municipal solid waste in Korea consists of miscellaneous materials with incombustible materials and large amounts of moisture, which prevent heat recovery from combusting. Due to fossil fuel limitation, technological development of renewable and sustainable energy such as waste to energy (WtE) is necessary. Solid refused fuel (SRF) mainly consists of combustible matter which is derived from municipal solid waste by separation process, and heat content was maximized by intensive drying process. Combustible matter in SRF contains plastics fraction to increase calorific value. In this study, commercial SRF boiler with 100MW capacity was selected to investigate corrosion issue in boiler tube and convection pass. Usually, chlorine content of fuel occur boiler tube corrosion, and alkali metals such as K, Na, Ca occur slagging and fouling. Based on the fuel analysis, the average chlorine content of SRF was 1.32%. In XRF analysis, the chlorine content in boiler tube ash and bottom ash was 6.1% and 4.3%, respectively. In SEM-EDX analysis, the chlorine content in corrosion part on boiler tube was ranged from 11.95% to 30.52%. Figure 1 shows the corrosion part of boiler tube and facility location which was occurred alkali-chlorine corrosion.

Acknowledgement: This work was also supported by Korea Institute of Energy Technology Evaluation and Planning (KETEP) and the Ministry of Trade, Industry & Energy (MOTIE) of the Republic of Korea (No. 20184030202240).

S11-9

Adsorption characteristics of strontium ions by pristine and magnetic biochars derived from spent coffee grounds

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The management and treatment of radioactive strontium generated from the nuclear power plant have been regarded as one of the important issues in the environmental engineering since the nuclear power plant accident of Fukushima-Daiichi in 2011 has released a huge amount of radioactive strontium which can cause acute and/or chronic carcinogenicities to human health and aquatic organisms even at very low concentrations. Although activated carbon adsorption is considered as the most common approach for the removal of Sr^{2+} from aqueous solutions due to its easy and simple operation, it still requires the high maintenance costs for the regular replacement of activated carbon. Therefore, biochars have drawn substantial attention as an eco-friendly and cost-effective adsorbent because of the abundant functional groups and large specific surface areas. However, the exhausted biochars after the adsorption may lead to secondary contamination which limited their widespread applications for the treatment of real aqueous nuclear wastes. In this study, the pristine and magnetic biochars were prepared using spent coffee grounds (SCG) to compare their adsorption capacities of Sr^{2+} and recovery efficiencies from aqueous solutions after adsorption. Furthermore, the physicochemical characteristics of the pristine and magnetic SCG biochars (i.e., surface crystallization, specific surface area, pore volume, surface morphology, elemental compositions, surface functional groups, and magnetic property) were rigorously characterized using various analytical methods and directly correlated to the observed adsorption kinetics, isotherm models, and thermodynamics to offer deeper insights into their adsorption mechanisms of Sr^{2+} from aqueous solutions. The additional results for the effects of the adsorbent doses, contact time, solution pH, and temperatures on the adsorption of Sr^{2+} by the pristine and magnetic SCG biochars will be shown in the full paper.

Keywords: Adsorption, Biochars, Magnetization, Spent coffee grounds, Strontium.

S11-10

PGPR Aided Zinc Application Improve the Productivity and Grain biofortification of Bread Wheat

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Zinc (Zn) deficiency is major micronutrient disorder in wheat, limiting the grain yield, grain quality and may lead to human Zn deficiency on people consuming wheat for major daily caloric intake. Plant growth promoting rhizobacteria (PGPR) helps enhance the Zn availability in rhizosphere thus increase Zn uptake and improve plant growth. This study was conducted to evaluate the effect of inorganic Zn application with or without combination of Zn solubilizing PGPR on performance and grain Zn biofortification of wheat. Zinc was applied through seed priming (0.5 *M*), seed coating (1250 mg g^{-1} seed), soil application (10 kg ha^{-1}) and foliar spray (0.025 *M*) alone or in combination of PGPR. Hydroprimed seeds were taken as control. Zinc application improved the performance of bread wheat. However, application of Zn in combination with Zn solubilizing PGPR further enhanced the crop performance through improvement in plant photosynthetic assessment traits, grain yield and grain biofortification of wheat. Zn application through seed priming and soil application in combination with PGPR enhanced the organic acid production from the root exudates of wheat. Moreover, soil and foliar application of Zn followed by seed priming alone and in combination with PGPR enhanced the Zn concentration in whole grain and all seed fractions (germ, aleurone and endosperm) with lower phytate accumulation and higher Zn bioavailability. In crux, Zn application through seed priming and soil application in combination with PGPR improve the grain yield, grain Zn concentration and bioavailability.

Key words: root exudates, zinc, photosynthesis, bioavailability

S11-11

Intrinsic chemical reaction of heavy metals in ice and its environmental implication and application

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The redox transformation of elements in various media is very critical to understand their fate in the environment. Especially, the redox speciation of heavy metals controls their mobility, bio-availability, and toxicity. Although the redox processes of toxic heavy metals such as chromium and arsenic have been frequently investigated in aqueous solution, their chemical behaviour in ice phase has rarely been studied. In our studies, chromium and arsenic species were selected as the standard toxic heavy metals for the study of redox chemical transformation in frozen state. We investigated both the reductive conversion of Cr(VI) and the oxidative transformation of As(III) in ice in comparison with their counterparts in aqueous solution. We found that the redox conversion of Cr(VI) and As(III) was significantly accelerated in ice phase compared to those in aqueous solution. The enhanced redox reaction in ice can be ascribed to the *Freeze Concentration Effect* (when solution is solidified the existed organic/inorganic compounds are separated from ice crystals and highly concentrated in unfrozen place or ice grain boundaries in ice) by freezing. The detailed experimental conditions and mechanism will be discussed in the presentation. We will also discuss the environmental implication and application.

Keywords: ice chemistry, redox reaction. Freeze concentration effect, heavy metal toxicity

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Session 12

Metal(loid)s in Metal mine environments: Biogeochemical processes and mineralogical immobilization

S12-1

Chemical and mineralogical heterogeneity of mining waste at Plombières (East-Belgium)

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Former mining sites often contain different types of waste materials (overburden, waste rock, tailings, etc.) which present an environmental risk, but which can also be considered a potential secondary resource. Metals as well as residual mineral fractions can be extracted from the waste, and replace primary raw materials in multiple applications. Because different types of waste materials are usually found at mining sites, the thorough characterisation of these materials is essential to evaluate their environmental impact, as well as their potential for metal recovery or other beneficial application. In the present study, a mineralogical and geochemical characterisation of different types of mining waste samples collected at the ancient Pb-Zn of Plombières was performed. Based on the mineralogical and chemical composition, different groups of samples were distinguished, and information on the solid phase speciation of Pb and Zn in these materials was obtained. The chemical composition of the samples was determined by ICP-OES (after digestion with for strong acids and lithium metaborate ($LiBO_2$) fusion). Mineralogical composition was analysed using XRD, and grain size distribution was determined by laser diffraction. The solid phase fractionation of heavy metals was determined by the BCR sequential extraction procedure in combination with XRD analysis. Many Pb/Zn-bearing minerals are present in the mining waste, including primary sulphides (galena and sphalerite), as well as secondary minerals such as willemite, cerussite, anglesite and plumbojarosite. Based on grain size, Pb and Zn concentrations, colour, and the presence of slag fragments, five groups of samples could be distinguished. A comparison of the results of the $LiBO_2$ and 4 acid digestion method showed that a better recovery of Pb was obtained by the 4 acid digestion method. The concentrations for Zn were similar for both methods. However, several samples (especially slag material) were not completely dissolved by both dissolution methods. Sequential extraction results, in combination with the mineralogical data obtained after the different extraction steps, indicate which minerals dissolved and are responsible for the release of heavy metals in each extraction step. However, precipitation of secondary minerals (e.g. anglesite), the incomplete dissolution of some minerals, and (de)sorption reactions have also to be taken into account.

Keywords: mine waste, heavy metals, mineralogy, sequential extraction

S12-2

Antimony in soils and mine waste heaps around the Mau Due antimony mine, North-Vietnam

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Antimony (Sb) is an element with a growing concern because of its toxicity, but also because of its criticality. While the impact of Sb mining is documented in literature from China and Europe, little data are available concerning the environmental impact of Sb mining in Vietnam (Isuhara and Xian, 2013). This paper presents the results of the geochemical and mineralogical characterization of mine waste and soil samples from the Mau Due mine (North Vietnam). The chemical composition of the samples was determined with ICP-OES, after acid digestion with 3 strong acids, and after $LiBO_2$ fusion. X-ray diffractions (XRD) analysis was used to determine the mineralogical composition of the samples. A quick assessment of the exchangeable Sb species was performed with the EN12457-2 test (extraction with water at a liquid to solid (L/S) ratio of 10), while the specifically sorbed Sb was extracted with $Na_2HPO_4.2H_2O$ (0.1 mol/l) (Ettler et al. 2007). The release of Sb at different pH values was investigated by single extractions with diluted NaOH solutions (L/S 10 l/kg). Antimony concentrations in the mine waste samples (slags and waste rock) was in the range 186- 27221 mg/kg, while soils were characterized by Sb concentrations in the range 31-91 mg/kg. The leaching of Sb from all the samples with water was relatively low, as less than 1% of the total Sb content in the samples was released. In absolute values, this resulted in water extractable Sb concentrations up to 46 µg/l, except for one mine waste sample, which released 1660 µg/l of Sb. In the latter sample, stibnite (Sb_2S_3) was detected by XRD analysis. Experimental leaching of Sb as a function of pH was compared with modelled results (VisualMinteq). Based on the outcomes of this reconnaissance study, recommendations for further investigation of the waste heaps around the mine were made, taking into account the protection of health and environment, as well as the sustainable management of secondary (waste) resources.

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Keywords: antimony, leaching, mining

S12-3

Recycling mechanochemically activated sulfidic mining wastes with blast furnace slag as alkali activated materials

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Sulfidic mining wastes pose profound threat to the environment due to the contamination of sulphide content and heavy metals (Cd, As, and Pb etc.). It always accumulates near the mining site as dumps which can lead to acid mine drainage along with the water circulation. Hence, it is important to find a versatile method for both remediation and recycling of those mining wastes. Alkali activation can be a promising method to achieve the objectives of recycling mining wastes as secondary raw materials and also to stabilize the heavy metals present in them. However, the pristine mine wastes are rather inert for alkali activation; therefore, it requires pre-treatment to enhance the chemical reactivity of wastes. Ground-granulated blast furnace slag (GGBFS) is a by-product from steel manufacturing which is highly reactive to produce cementitious binders. GGBFS has been used in producing alkali activated materials with high performance of mechanical properties and heavy metal stabilization when the ettringite-based binder exists. It is interesting to develop a synergy between sulfidic mining wastes and GGBFS in alkali activated materials with favourable mechanical properties. The mechanochemical activation is a greener and more efficient way to improve the chemical reactivity of mining waste when compared with heat-treatment and chemical treatment. Mechanochemically activated mining waste (MAMW) can substitute part of GGBFS in producing alkali activated materials. It is interesting to investigate the alkali activated materials with different content (10 % to 90 %) of MAMW replacing GGBFS. Compressive strength was measured after curing at 7th, 14th and 28th day under the sealing condition at room temperature. XRD, FTIR, XPS, NMR and SEM were utilized to evaluate the synthesized inorganic polymer. Leaching of heavy metal leaching performance was studied using ICP-MS after soaking test for each sample in different conditions (H_2O, HCl, NaOH and NaCl). The mechanism of heavy metal stabilization will be pointed out after the analysis.

This study displays the potential application of alkali activated MAMW with GGBFS as construction and building materials. The ettringite-based binder stabilizes heavy metals in the matrix of resultant alkali activated materials and the behaviours of different hazardous metals were investigated based on preceding characterizations.

Keywords: Sulfidic mining wastes, GGBFS, alkali activated materials, heavy metals

S12-4

Characteristics and leaching of heavy metal(loid)s from geopolymers produced from mine waste

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Mine waste is of growing concern, as huge amounts of waste have been stored during the last centuries, and millions of tons of mining waste are still generated every year. Proper storage of mine waste requires abundant space and, if improperly managed, can cause environmental degradation. Environmental concerns are especially pertinent in the case of sulfidic mine waste, in which acid mine drainage can be an issue. Proper immobilization of the heavy metal(loid)s (e.g., geopolymerization) can decrease the environmental risks the mine waste poses. Given the abundance of sulfidic mine waste, there is a large opportunity to utilize this waste by valorizing the material into eco-friendly building materials, while at the same time stabilizing the heavy metal(loid)s. Alkali-activation (i.e., geopolymerization), is an effective stabilization method for the management of waste materials (Payá et al., 2015). In the present study, sulfidic mine waste is valorized into geopolymers using blast furnace slag as a co-binder to immobilize the heavy metal(loid)s. The efficiency of the stabilization was evaluated based on the results of leaching tests performed on the geopolymers in relation to the raw mine waste before valorization. To determine the mobility of the contaminants within the geopolymers made from mine waste, standardized leaching tests (e.g., EN 12457-2 and U.S. EPA Toxicity Characteristic Leaching Procedure (TCLP)) were performed. The same leaching tests were performed on the raw mine waste for comparison. In addition, a standardized leaching test specifically for monolithic building materials containing waste (i.e., NEN 7375 diffusion test) was also applied to the geopolymers to study the leaching behavior. Leaching tests confirmed that the stabilization of the mine waste in geopolymers decreased the leaching of heavy metal(loid)s in comparison to the raw mine waste. Therefore, the geopolymerization process can be a beneficial way to utilize and valorize mine waste. The solution is twofold: the contaminants in mine waste are stabilized, eliminating the environmental risks; and through valorization, eco-friendly building materials are created.

Keywords: immobilization, geopolymers, leaching tests, valorization

Payá, J., Monzó, J., Borrachero, M. V, Tashima, M.M., 2015. Reuse of aluminosilicate industrial waste materials in the production of alkali-activated concrete binders, in: Handbook of Alkali-Activated Cements, Mortars and Concretes. pp. 487–518. https://doi.org/10.1533/9781782422884.4.487

S12-5

Mobility and oral bioaccessibility of metals from tailing materials of Romania

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Mining activities have an important negative impact on environment due to the production of wastewater, mine tailings and a lot of dust which generally contains a large amount of metals. The mine tailings of Bozanta and Anies, in Romania, were investigated by the combination of solid-phase analyses, mineralogical methods, solubility, bioaccessibility and compliance tests, and speciation modelling, in order to assess the processes governing the contaminant mobility, and to evaluate the risks for the surrounding environment. Tailing samples have been collected at Bozanta and Anies tailing impoundments located in two of the former most important places (Baia Mare and Rodna, respectively) for mining and non-ferrous metallurgy (gold-silver ores, copper, lead, zinc). In both areas, the mining and ore processing activities were decommissioned between 2009-2012, however, dozens of tailings dumps and ponds bear witness to this past activity. Bulk chemical analyses indicated that tailing samples contained significant amounts of contaminants among other: up to 2170 mg/kg Zn, 1000 mg/kg Pb and 785 mg/kg Cu. Tailings mineralogy still contain primary minerals such as sulfides (e.g., pyrite, arsenopyrite, sphalerite,), carbonates (e.g., dolomite, siderite), felspar and quartz. Sulfates (e.g., gypsum, barite and langite) and Fe and/or Mn oxides s.l. are the main secondary metal-bearing phases. Equilibrium pH of the leachates based on EN 12457-2 test are neutral to highly acidic depending on the tailing samples, and release of both sulfate and metals is high for all samples, due to sulfide oxidation. Bioaccessible fractions of the major contaminants estimated by glycine extraction (US EPA, 2007) were high and reached up to 70 % of total Pb, 50% of Zn, and 25% of Cu. The daily oral intake has been estimated according to Baars et al. (2001) and exceeded tolerable daily intake limits for Pb in some tailing samples from Anies and Baia Mare. Our results show that both environmental and human risks exist in the close vicinity of tailings and that appropriate safety measures must be taken.

S12-6

The Brumadinho dam failure: what can we learn from Pb isotopes measured on suspended material?

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Last 25 January 2019, the Córrego do Feijão tailing dam collapsed close to Brumadinho city (Minas Gerais, Brazil), leaving over 250 people dead. At least 10 M $m^3$of tailing were spread into the small watershed of Ferro-Carvão (FC), and only a part until the Paraopeba River, one of the most important tributaries of the São Francisco River. The Paraopeba River has a great importance for the local population, largely used for water harvesting, fishing, leisure, transport and supply the Retiro baixo and Tres Marias hydroelectric plants. The sources, the behaviour and the dynamics of potential contaminants present in the wastes must be understood in order to reduce pollution and propose reclamation methods. Quick after the disaster, a water and sediment sampling campaign has been undertaken, and 13 superficial water samples were collected and analyzed across 370 km until Tres Marias reservoir, from few days to four months after the disaster. The aim was to investigate the dissolved and particle-bound trace element contamination and the potential sources of pollutants, through elemental geochemistry and Pb isotopic composition on suspended particulate matter (SPM) and sediments. Upstream the spilling, the SPM concentration ranged from 35 to 45 mg/L, while at the confluence between the Paraopeba River and the Ferro-Carvão stream, it reached values up to 40,000 mg/L, even four months after the disaster. Downstream the confluence, the SPM concentration in the Paraopeba river varied from 18 to 49 mg/L and decreased to ca 7 mg/L at the Retiro Baixo reservoir. The SPM was mainly composed of Fe and Si. The dissolved and SPM metals content remained low and no variation in metal content was observed from mine to downstream. The Pb isotopic composition of SPM varied largely from mine to downstream, and Pb isotopic signatures in SPM resulted from a simple binary mixing of two sources of Pb: a natural source corresponding to the geochemical background of the mine, and an urban source including gasoline.

Combining geochemical and isotopic information allows us to discuss the impact of Brumadinho dam failure on the particulate contamination of the Paraopeba River basin.

S12-7

Community Variation and Metal Biotransformation of Microbes in Alkaline Copper Mine Contaminated Sediments

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Heavy metals in aquatic environment, as a typical nonbiodegradable contamination, has caused great concern worldwide. Microbes, populated in riverbed sediments, plays an important role in metal biotransformation. However, little is known about the microbial community variation and metal biotransformation in responses to the alkaline copper mine pollution. In this study, the composition variation, co-occurrence pattern, indicator genera, and copper biotransformation of sediment microbial communities were studied in the Jinsha River contaminated by alkaline copper mine drainage. Results showed that significant sulfur (TS, 13.92 ± 2.64 g/kg) and copper (Cu, 976.7 ± 103.9 mg/kg) pollution caused significant decreases of bacterial and fungal diversities in these polluted sediments. Moreover, redundancy analysis and mantel test showed that both bacterial and fungal community compositions were influenced by copper, sulfur, nitrate-N, organic-C, and pH values. Co-occurrence network analyses indicated that long-term alkaline copper mine contamination shaped a less complex but more stable microbial interaction pattern with more positive microbial associations and higher network connectivity at polluted sites. Indicator genera that identified from polluted sediments, such as *Dethiobacter*, *Symbiobacterium*, and *Thiovirga*, were legacy microbial communities from alkaline copper mine contamination, with more functional groups related to the cycling of sulfur, copper, and other metals. PICRUSt analysis suggested that these microbes contained well-conserved copper resistance systems, including the Cu^+/Cu^{2+}-exporting ATPase (*cop* system), copper oxidase system (*pco* system), and Cu^+/Cu^{2+} efflux system (*cus* system), which can weaken copper biotoxicity and maintain microbial functions. Therefore, long-term alkaline copper mine pollution made microbes that had strong tolerance against copper and could grow readily become new dominating ones, and shaped a more stable microbial co-occurrence pattern. These copper-resistant microbes show promise for use in biological remediation of alkaline copper contaminated sediments.

Keywords: Alkaline copper mine pollution; Jinsha River; Metal biotransformation; Microbial community; Sediment.

S12-8

Acidified Biochars to Improve Heavy Metal Solubility in An Alkaline Mine-contaminated Soil

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Soil contamination by heavy metals is considered as one of the most severe concerns for human health and ecosystem. Bioremediation for heavy metal removal from soils has been used because of low cost of implementation and less environmental impacts. However, remediation efficiency is low particularly in alkaline-metal contaminated soils due to high soil pH causing metal precipitation and low mobility. In this study, effects of biochar application on heavy metal solubility and fractions in an alkaline mine-contaminated soil were studied. Pristine and acidified biochars were applied and incubated for 56 d. Citric acid was used for comparison. Water-soluble and exchangeable as well as fractionation of Cd, Cu, Pb, and Zn were analyzed. Citric acid application lowered soil pH from 8.0 to 3.3, thus significantly solubilized all heavy metals. Exchangeable fraction significantly increased for all heavy metals with citric acid. Pristine and acidified biochars did not change soil pH probably due to low application rate (2% w/w). However, application of both biochars increased solubility of Cu and Zn possibly due to complexation with dissolved organic carbon (DOC), but not for Cd and Pb. It was indicated that DOC and cation exchange capacity of biochar were important properties that could affect metal solubility in contaminated soils but not so much from acidified nature of biochar itself.

Keywords: chelator, fractions, Mexico, oak sawdust, SEM-EDS

S12-9

Availability and mobility of chromium in ultramafic areas affected by mining activities: An isotopic study

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Ultramafic systems may display high chromium (Cr) concentrations. Chromium may be naturally leached from weathering profiles like laterite to surface and groundwater. However, mining and metallurgical activities may considerably increase the amount of both trivalent and hexavalent chromium (Cr(III) and Cr(VI)) released into the environment, the later being highly soluble in water, bioavailable and toxic. In the present study, a nickel mining area was studied in Goiás State, Brazil (Barro Alto) in order to compare the potential release of Cr(VI), its pathway from solids to surface and ground waters, and its associated isotopic compositions in those matrices. Fe oxy-(hydroxides) were identified by X-Ray Diffraction as the main Cr-bearing mineral phases. The chemically and isotopically exchangeable pool of Cr(VI) (ECr(VI)) was higher in ores with values up to 104.09 (± 7.70) mg kg^{-1}. In soils, the ECr(VI) in the deep soils was up to 30 fold higher than in the surface (up to 6.66 (± 1.05) mg kg^{-1}). This was accompanied by an increase of δ^{53}Cr, which varied from -0.28 (± 0.01) ‰ to -0.05 (± 0.01) ‰. In addition, Cr(VI) chemically extracted (KH_2PO_4) also displayed positively fractionated δ^{53}Cr (1.69 (±0.03) ‰) in the same range of isotopic compositions measured in the fresh waters. These results suggest that Cr is mainly released as the toxic Cr(VI) specie, which availability increases from the soil profile to the ores and mining residues. The differences observed in the Cr isotopic composition suggest that δ^{53}Cr could be used as a tracer of Cr leaching in environmental studies.

Keywords: Stable isotope, Chromium, Mobility, Mining impact, Geochemistry

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Session 13

Metal contents in cultivated crops: Nutritional needs versus food safety

S13-1

Intercropping of *Pteris vittata* and maize can simutaneously improve food safety and combat iron malnutrition

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Intercropping of arsenic (As) hyperaccumulator *Pteris vittata* L. and low accumulating crop is an important safe utilization method for As contaminated soil. It is required to improve the economic benefit of agricultural production and the removal rate of toxic As. However, these two aspects usually contradict each other. Therefore it is hard to propose feasible optimizing strategy for the intercropping system. Utilizing multiple in situ observation methods for root exudates, and phyto-available As and iron (Fe) distribution in the soil-plant system, this study aimed to investigate: (1) role of the phytosiderophores secreted by maize in improving the As accumulation by *P. vittata*; (2) role of the phytic acid secreted by *P. vittata* in improving the concentration and bioavailability of Fe in maize. Based on results from this model intercropping system, the optimizing strategies, including intercropping density, and the appropriate amendments, are to be proposed for the intercropping systems of *P. vittata* and other high-value cash crops. Results of the current study will illustrate the synergistic effect of contaminants and mineral elements under the intercropping system, contributing to the intercropping theory of hyperaccumulators and low accumulating crops, and providing direct guidance for the safe utilization of As contaminated soil.

Keywords: arsenic, intercrop, iron, maize, *Pteris vittata*

S13-2

Session 13

Phytoremediation of Zn contaminated soil using Alfalfa enhanced by EDDS

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Mono-contaminated soils may provide opportunities to extract and recover essential trace metals. Biofortified feed crops grown on soils specifically contaminated with these elements could decrease the needs for supplementation of animal feed with metals such as Cu or Zn. To investigate the effects of EDDS application on phytoextraction of Zn, a pot experiment using Alfalfa (*Medicago Sativa L.*) was conducted for five months using three soils with Zn concentrations (in mg kg^{-1}) of 189 (A soil), 265 (B soil) and 1496 (C soil). The soil did not exhibit contaminations with other heavy metals or organic pollutants (mono-contamination). An agronomic strategy of consecutive cuttings of alfalfa shoots was applied as follows: the first cut was performed when the alfalfa was in late bud to full bloom period and subsequent cuttings were done at 32-day intervals. EDDS at different concentrations (0 as control, 0.5, 2 and 5 mmol kg^{-1}) was applied seven days after the second harvest. The results demonstrated that alfalfa can grow on Zn contaminated soil and accumulate Zn in its shoots, and thus is suitable for phytoextraction. EDDS application significantly increased Zn accumulation in the shoot of the biomass obtained with the third cut when compared with the controls in the three tested soils: 208%, 269% and 362% increase for Zn accumulation in the shoots of plants cultivated in the A soil; 107%, 140%, and 84% for the B soil; 100%, 140% and 108% for the C soil, respectively for the three rates of EDDS. For the A soil, the maximum Zn accumulation in the shoots of the third cut (0.53 mg pot^{-1}) was obtained when the maximum EDDS concentration (5 mmol kg^{-1}) was applied; however, the plants grown in soils B and C had the highest Zn accumulation (0.23 and 0.22 mg pot^{-1}) with the application of the intermediate EDDS concentration (2 mmol kg^{-1}). This was in accordance with the Zn uptake in the whole plants. Nevertheless, the application of 5 mmol kg^{-1} EDDS inhibited alfalfa growth when compared to the controls, with the reduction of 79%, 41% and 21% in shoot biomass production in the third cut in soils A, B and C, respectively. Therefore, in order to improve the phytoextraction efficacy of Zn while minimizing the phytotoxicity, the application of 2 mmol kg^{-1} EDDS is the best choice for phytoremediation of the three target soils using alfalfa. Furthermore, the translocation factors of Zn in alfalfa were above 1 in all tested conditions except in C soil. This was possibly related to the consecutive cuttings strategy adopted. Thus, the consecutive cuttings as an agronomic strategy for perennial plants such as alfalfa might be an option to enhance phytoextraction in practical applications. Further investigations will also focus on the potential re-use of the extracted Zn towards animal feed strategies, considering the targeted addition of Zn in feed mixes in modern animal husbandry.

Keywords: Alfalfa, EDDS, consecutive cuttings, phytoextraction, Zn

S13-3

Se and Zn biofortification of soybean (*Glycine max*) and enhancing its biochemical functions for the human nutrition improvement in the Se/Zn deficient regions

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Currently, up to 1 billion people are estimated to be affected by Se deficiency, and about 2 billion by Zn deficiency that create severe and complex health problems. Moreover, long-term observation-based predictions show the expanding Se deficiency regions due to climate changes. Soybean (*Glycine max*) as one of the world's most important protein crops can play a leading role in addressing global food security, in particular that along with rice, its yield appeared to be the least affected by the climate change since 1980 compared to wheat and maize. The pot experiment on Se and Zn biofortification of soybean seeds by applying 15 different soil treatments with these elements in the form of L-Selenomethionine and EDTA-Zn, alone or in dose combinations, during the soybean flowering phase, was carried out with the aim to achieve the best Se/Zn accumulation efficiency and the physiological status of the plants. The experiment conducted on the Se-deficient soil with Zn content within the global average, resulted in up to over 25-fold Se and 190-fold Zn enrichment in seeds (beans) compared to control plants. Application of Se alone, besides Se accumulation in soybean, reduced Zn uptake from soil, but caused alterations in Zn translocation and its multiple enrichment in beans. Zn alone promoted both Zn and Se enrichment. Joint Se/Zn application in increasing doses appeared to have strong synergistic effect on each other element accumulation in beans and enhanced the biochemical functions of soybean that manifested itself in the growth of photosynthetic production and soybean biomass, and in the improvement of lipid peroxidation status (REC, MDA and proline content indices), up to the toxicity symptoms indicating maximum Se/Zn doses. Several-fold higher content of Se and Zn in soybean straw compared to spiked soil suggested its possible use as Se/Zn-rich soil amendment in accordance with the circular economy goals. These novel findings may significantly contribute to human health in the Se and Zn deficient regions.

The contribution of IEE-PAS (Poland) to this study was performed within its statute activity, project No. 1a-120/2019

Keywords: Se/Zn deficiency in humans, Se/Zn biofortification; soybean, biochemical status

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Session 14

Advances in heavy metal remediation technology

S14-1

Phytostabilization potential of *Miscanthus* × *giganteus* and novel seed-based hybrid on heavy metal contaminated arable land

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Miscanthus is a highly productive perennial energy crop well suited to diverse climates and environments. *Miscanthus* combines a unique set of physiological traits and agronomic characteristics to allow sustainable productivity (i.e. with low inputs) even on lower grade marginal land types, including land contaminated with heavy metals (HMs). The goal of the presented study was to assess lead, cadmium and zinc concentrations in rhizomes, roots and shoots of *Miscanthus* × *giganteus* (M×g) and a novel *Miscanthus* seed-based hybrid (GNT41) cultivated on randomized experimental plots on HM contaminated arable land in Poland. Before planting, soil samples were taken to determine basic soil parameters, including total and bioavailable lead, cadmium and zinc. After the 4th growing season soil cores were taken to reassess soil parameters, plant rooting depth, and HM concentration in below and above ground plant biomass. Bioconcentration and translocation factors were then calculated. Average total soil concentrations of lead (500 mg kg^{-1}), cadmium (20 mg kg^{-1}) and zinc (1900 mg kg^{-1}) were several times over limits prescribed for agricultural soils. Highest plant metal concentrations were found in roots (about 50, 20 and 750 mg kg^{-1} for Pb, Cd and Zn, respectively), whilst rhizomes and shoots had similar levels (about 8, 1.5 and 150 mg kg^{-1} for Pb, Cd and Zn, respectively). Both M×g and GNT41 showed very low bioconcentration (shoot/soil ratio) and translocation factors (shoot/root ratio), demonstrating a degree of HM exclusion by *Miscanthus*. It was also found that seed-based hybrid uptakes lower amount of HM to the shoots, when compared to standard M×g. In this context *Miscanthus* shows suitability for phytostabilization, since low levels of HMs permit downstream utility of harvested biomass for thermal and anaerobic digestion conversion routes without the need for pre-treatment. Research was financed by the Polish National Centre for Research and Development (NCBiR) and the UK Department for Environment, Food & Rural Affairs (DEFRA), under the flag of Era-Net Cofound FACCE SURPLUS, in the frame of the Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI).

Keywords: *Miscanthus*, heavy metals, phytostabilisation.

S14-2

Adsorption of heavy metals to anaerobic ammonium oxidation (anammox) consortia: Implications for heavy metal removal in wastewater treatment system

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Anammox-based processes and microbial consortia have drawn extensive attention for their use in high-efficiency wastewater treatment technologies. Heavy metals substantially affect the activity of anammox consortia and the quality of wastewater treatment plant effluent. Here, we conducted acid-base titrations to ascertain the surface reactivity and proton adsorptive capacity of anammox consortia. A combination of titration data modeling and infrared spectroscopy suggested the presence of carboxyl, amine, and hydroxyl groups. Adsorption edges of single metal cations indicate that the adsorption preference was in the order: Pb(II) > Cd(II) > Cr(VI). A competitive effect was observed in multi-metal cations systems, with Pb(II) being preferably adsorbed and the degree of adsorption somewhat reduced in the presence of either Cd(II) or Cr(VI), while Cd(II) and Cr(VI) were easily exchanged and substituted by other metals. FTIR and XPS further suggest that the adsorption of Pb(II) and Cd(II) are as inner-sphere ion-exchange mechanisms, while Cr(VI) adsorption is mainly by outer-sphere complexation. Furthermore, density functional theory calculations reveal that considerable carboxyl and hydroxyl groups promote bacterial aggregation by forming stable cation complexes, and thus solid-liquid separation. The results of this study highlight the potential role of anammox consortia in adsorbing metal cations, and thus help to improve the understanding of the universally significant contribution of anammox consortia at the detoxification of metal cations in wastewater treatment systems.

Keywords: anammox, heavy metals, adsorption, wastewater treatment

S14-3

Biochar produced from drinking water sludge and its use for Pb^{2+} adsorption

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Drinking water sludge (DWS) is generated during the production of drinking water from water treatment plants to remove colour, humic substances, etc. It is inevitable and largely underutilized and has long been disposed of in landfills, leading to the occupation of land resources and a waste of resource. The search for more economical and sustainable disposal or reuse options is urgently needed. Biochar is attracting attention due to its potential for soil improvement, environmental remediation, and mitigation of climate change. It can be produced by the pyrolysis of organic materials, such as wood, straw, sewage sludge, pig mature, etc. However, DWS-derived biochar has not been explored. In this study, biochar was produced from DWS and their physiochemical properties at different pyrolysis temperatures (300°C, 500°C and 700°C) were also investigated. In order to discuss the Pb adsorption mechanisms, batch adsorption and sequential extraction tests were also conducted to produce adsorption kinetics and isotherms and the speciations of adsorbed Pb^{2+} in biochar. The microstructural analysis was also conducted the assist the adsorption mechanism exploration. The pH of biochar increased from 4.91 to 7.78 with the increasing pyrolysis temperature from 300°C to 700°C while the yield saw a decreasing trend from 60.18% to 43.18%. Compared with biochar produced from other organic matter rich materials, the DWS-derived biochar was found to contain more ash content and there was an upward trend from 59.21% to 85.01% with the increase in the pyrolysis temperature. Batch adsorption studies showed that the adsorption of Pb on DWS-derived biochar was completed within 24 hours. Both the Langmuir model and Freundlich model can describe the adsorption process despite the better fitting of the Freundlich model. The maximum adsorption capacity saw an upward trend from 37.39 mg/g, 71.01 mg/g to 71.04 mg/g when the pyrolysis temperature increased from 300°C, 500°C to 700°C. The microstructure of raw biochar and saturated biochar as well as the Pb speciations will also be discussed in this study. The comparison with biochar derived from other resources, especially sludges, will also be provided.

Keywords: drinking water sludge, biochar, adsorption, lead

S14-4

Potential of *Lactobacillus* spp. isolated from fermented cocoa to reduce the bioaccessibility of Cd or As

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The role of gut microbiota on the absorption of toxic elements in the human organism and the consumption of probiotics as an alternative to detoxify the human body and prevent diseases has been an important topic of research recently. The aim of this study was to evaluate the potential of lactic acid bacteria isolated from fermented cocoa, to remove cadmium and arsenic under *in vitro* conditions of acidity and salinity that simulate the human digestive system, in order to verify their potential in future detoxification applications. A total of 38 *Lactobacillus* spp. strains resistant to Cd(II) or As(III) were isolated from fermented cocoa, at Caldas, Colombia, and identified by molecular methods. The most resistant bacteria to Cd(II) or As(III) were selected by Minimum Inhibitory Concentration, and from this pool the most tolerant to *in vitro* conditions of acidity and salinity were selected. With these criteria, reference strain *L. plantarum* JCM 1055 and native isolates *L. plantarum* C16 and *L. plantarum* A19 were selected for further analysis. These strains were evaluated for their Cd(II) or As(III) removal capacity in aqueous media. 100% removal of cadmium was observed for all three strains (using 0.1 mg/L Cd(II), pH 5 and 1.5 g/L bacterial biomass), while the best removal percentage of arsenic was 20% with *L. plantarum* C16 (using 0.1 mg/L As(III), pH 5 and 1.5 g/L bacterial biomass). Also, it was evaluated the ability of these bacteria to decrease the bioaccessibility of Cd(II) or As(III) under *in vitro* conditions of the human digestive system, according to the RIVM (Rijks Instituut voor Volksgezondheid en Milieu) model. Native isolate *L. plantarum* A19 reduced Cd(II) bioaccessibility to 56% and As(III) bioaccessibility to 62%. These bacteria present a great potential to detoxify Cd(II) or As(III) that could be evaluated using *in vivo* models.

Keywords: arsenic, cadmium, detoxification lactobacilli, removal, RIVM model.

S14-5

Efficient Immobilization of Municipal Solid Waste Incinerator Fly Ash by Phosphate-Enhanced Calcium Aluminate Cement

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Disposal of municipal solid waste incinerator fly ash (MIFA) presents significant environmental burdens. This study proposed a novel and efficient method for stabilization/solidification (S/S) of MIFA by phosphate-modified calcium aluminate cement (CAC). X-ray diffraction and thermogravimetric analyses showed that 10 wt% incorporation of CAC drastically reduced leachability of Pb in MIFA by 96.2%. However, the addition $Pb(NO_3)_2$ retarded the early-age hydration of CAC. The addition of phosphate additive (10 wt% of binder), such as trisodium phosphate (TSP), effectively mitigated the negative impact of Pb on the hydration process and significantly increased the early strength of the mortar. Scanning electron microscope (SEM) and element mapping results demonstrated that phosphate additive directly combined with Pb^{2+} to form a precipitate of $Pb_3(PO_4)_2$. The incorporation of TSP (10 wt%) in the binder was the most effective. Overall, this study indicated that phosphate-modified CAC is a promising material for the S/S of toxic metals in MIFA.

Keywords: hazardous waste; calcium aluminate cement; toxic elements; stabilization/solidification; lead leachability; incinerator fly ash.

S14-6

Research on single/compound reduction stabilization and its long-term stability of remediation effect of Cr(VI) contaminated soil in cold region

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Freeze-thaw erosion is a potent environmental force that has an significant effect on the biogeochemistry of heavy metals in middle to high-latitude regions. Among the toxic metals in soil, chromium have attracted much attention due to its high toxicity and mobility, which brings great challenges to soil remediation in cold regions. In order to seek for a suitable remediation approach for Cr(VI) contaminated soil in seasonally frozen areas and ensure its long-term effectiveness, four different treatments, namely ferrous sulfate application ($FeSO_4$), calcium polysulfide application (CPS), joint application of biochar and calcium polysulfide (BA+CPS) and control group (BL) were set up. Three moisture content levels (initial water content of 10%, 20% and 30%) were set for each treatment, and the reduction rate and stabilization performances of Cr(VI) were tested. Furthermore, the freeze-thaw cycle treatment was performed on the soil samples after stable remediation, and the leaching behavior as well as geochemical fractions of Cr(VI) were explored through sequential extraction procedure. The results reveal that the Cr(VI) reduction rates of $FeSO_4$, CPS and BA+CPS treatments were 45.8%~52.7%, 76.5%~82.3% and 80.1%~85.4%, respectively. With the increase of water content, the reduction of soil Cr(VI) gradually increased. The stabilization performance of BA+CPS was significantly better than that of $FeSO_4$ and CPS treatment. Freeze-thaw erosion damages soil structure and increased risk of Cr leaching, and a high initial moisture content favored the migration of Cr. The BA+CPS treatment reduced the leachate concentrations of Cr(VI) effectively, and biochar could also immobilize Cr(VI) through adsorption. In the simulated leaching test, the release of total Cr and Cr(VI) in BA+CPS treatment was reduced by 86.37% and 90.25%, respectively, compared with the soil without stabilization. Meanwhile, total leachate Cr concentration under $FeSO_4$, CPS and BA+CPS treatments decreased by different degrees, compared to BL, and the effect of BA+CPS on leachate Cr removal was the most significant. Results from analysis of geochemical fractions reveal that BA+CPS treatment effectively promoted the redistribution of metal fractions from labile forms to less labile forms. This research provides insights into the simultaneous reduction and stabilization of Cr(VI) in contaminated sites in cold regions.

Keywords: Freeze-thaw erosion; hexavalent chromium; remediation strategies; leaching behavior.

S14-7

Green remediation of Cd and Hg contaminated soil using humic acid modified montmorillonite: immobilization performance under accelerated ageing conditions

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Solidification/Stabilization (S/S) is an effective way to immobilize toxic metals in contaminated soil. However, utilization of ordinary Portland cement (PC) in this process has raised environmental concerns owing to the high carbon footprint from PC manufacturing and the risk of toxic element leaching in the long term. Hence there is an urgent need to seek for "green" immobilization approaches with long-term stability. In this study, a clay-based material, humic acid modified montmorillonite (HA-Mont) was applied to a Cd and Hg contaminated soil. Field emission scanning electron microscopy combined with energy-dispersive X-ray spectroscopy (FESEM/EDS), N_2 adsorption-desorption, Fourier transform infrared (FTIR) spectroscopy and X-ray diffraction (XRD) analyses were performed to investigate the characteristics of this material. Compared to the soil without any treatment, dosage of 5% HA-Mont could effectively reduce Cd and Hg concentrations by 94.1% and 93.0%, respectively and to below the regulatory limits in the TCLP (Toxicity Characteristic Leaching Procedure) leachates. Compared to the soil treated with virgin montmorillonite, HA modification resulted in the reduction of leachate concentrations of Cd and Hg by 69.5% and 65.9%, respectively. Long-term immobilization performance of the HA-Mont treatment was examined using a quantitative accelerated ageing method. In order to examine the ageing features, a novel method based on conditional probability was developed, and the reliability of HA-Mont immobilization was found to fit the Weibull model well, as the ageing rate of immobilization effect increased with time. After 120 years of ageing, reliability of both metals could still remain above 0.95. Cd concentration in TCLP leachates at 120th year could still remain below the regulatory limit (294 μg/L vs 1000 μg/L), while Hg concentration reached the regulatory limit of 200 μg/L in 96th year. This is the first attempt developing a green S/S method of Cd and Hg contaminated soil using HA-Mont and examining the long-term ageing characteristics of the stabilized soil using a probability-based approach.

Keywords: clay minerals; metal immobilization; accelerated ageing; long-term leachability; probability-based approach.

S14-8

Assessing the effects of biochar and organic fertilizer on bioavailability and speciation of heavy metals in seasonally-frozen farmland soils

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Most of the region located in middle latitudes are experiencing seasonal freezing and thawing processes that change the physiochemical properties of soil and increase the environmental risks associated with migration of heavy metals. In order to mitigate the risks associated with heavy metals, four treatments were set up, including biochar addition (BA), organic fertilizer addition (OA), biochar and organic fertilizer combination addition (CBO) and control group (BL), to stabilize Pb and Cd co-contaminated soil. The freeze-thaw cycles under different freezing degrees (freezing temperature - 10, - 20, - 30 ℃) were conducted. The stability of soil aggregate, the content of soluble organic carbon, the speciation of heavy metals in soil and their bioavailability were analyzed, and the effects of freeze-thaw cycle on the long-term stability of heavy metals in soil were explored. The results reveal that the freeze-thaw cycle reduced the stability of soil aggregates. As the number of freeze-thaw cycles and the freezing degrees increased, the proportion of soil small particle aggregates (<0.106mm) gradually increased, while BA, OA and CBO amendment effectively promoted the formation of medium particle aggregates (0.106 ~ 0.5mm). Freeze-thaw cycle increased the proportion of labile forms of heavy metals (i.e., exchangeable), which increased the risk of heavy metal release. Meanwhile, the soluble organic carbon released by aggregate cracking formed soluble complexes with heavy metals, thus increasing the metal mobility. Biochar can effectively increase the stability of soil organic carbon through adsorption, and reduce the mobility of heavy metals in soil. Under CBO treatment, the proportion of exchangeable fractions of Cd and Pb in the soil decreased by 5.72% ~ 13.48% and 7.97% ~ 17.86% compared with the BL, respectively, and the proportion of metal bound to carbonates and residual fraction increased in different degrees compared with BL. Bioavailability of heavy metals in frozen and thawed soil increased, the increase of freezing strength favored this process. It is suggested that the CBO amendment is the most effective way to immobilize Pb and Cd. This study shed light on the risk containment and sustainable remediation of farmland soils in cold region.

Keywords: seasonal freeze-thaw cycle, contaminated soil, remediation strategies, bioavailability, long-term effectiveness

S14-9

Green immobilization of toxic metals using alkaline enhanced rice husk biochar: effects of pyrolysis temperature and KOH concentration

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Biochar is a "green" material that has been widely used in environmental applications for its capability in removing or immobilizing contaminants in different environmental media (i.e. soil, water and air) and mitigate climate change. In this study, the feasibility of using KOH enhanced biochar for soil Cd and Pb stabilization was investigated, and the effects of pyrolysis temperature and alkaline concentrations for modification were explored. Field-emission scanning electron microscopy (FESEM), N_2 adsorption-desorption and Fourier Transform Infrared Spectroscopy (FTIR) analyses were conducted to reveal their influence on biochar physiochemical properties. The immobilization performances were monitored through Toxicity Characteristics Leaching Procedure (TCLP), and Response Surface Methodology (RSM) was adopted to visualize the results from leaching tests. The stabilization mechanisms of alkaline enhanced biochars were investigated using Time of Flight Secondary Ion Mass Spectroscopy (TOF-SIMS), Tessier sequential extraction method and X-ray diffraction (XRD) analyses. The results indicated that rice husk biochar pyrolyzed at a relatively low temperature (i.e., 300 °C) and activated by moderate alkaline concentrations (1 M or 3 M KOH) rendered optimum stabilization performance. KOH activation was a double-edged sword, with high alkaline concentrations destroying biochar cell structures. Moreover, the integration of TOF-SIMS, XRD and sequential leaching method shed lights on the underlying mechanisms. Surface complexation between toxic metals and oxygen-containing functional groups rather than liming or precipitation was proven to be the fundamental stabilization mechanism in soil heavy metal immobilization.

Keywords: engineered biochar; alkaline activation; metal stabilization; TOF-SIMS; immobilization mechanism.

S14-10

Vanadium Biogeochemistry and Bioremediation

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Mineral smelting and fossil fuel combustion activities release large amount of vanadium into geological environment, resulting environmental pollution. The toxicity of vanadium increases with the increase of valence. Pentavalent vanadium [V(V)] is the most toxic. This study reveals biogeochemical processes of vanadium in Panzhihua, China, world-famous for vanadium storage and production. Vanadium distributions and microbial responses are studied. Soil at smelting site is the most heavily contaminated, and its vanadium content is multiple times higher than background value. Vanadium has strong impacts on microbial communities. The migration and transformation of vanadium is significantly affected by co-existing electron donors (organics, hydrogen and methane), electron acceptors (nitrate, sulfate) and pollutants (chromate, pentachlorophenol). Indigenous microorganism can successfully bioreduce V(V) to less toxic and insoluble tetravalent vanadium [V(IV)], achieving in situ remediation. Supplementary solid inorganic electron electrons as elemental sulfur and zero-valent iron can support this biotransformation efficiently. Bioelectrochemical intensification can further improve the effectiveness. This study is helpful to reveal biogeochemical fates of vanadium in smelting site and provides promising alternatives to successful remediation.

Keywords: Vanadium; Biogeochemistry; Heavy metal; Bioremediation

S14-11

Decrease of arsenic release from paddy soil by encapsulated calcium peroxide(CaO_2) nanoparticle and biochar

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Introduction of biochar to heavy metal contaminated soil has emerged due to the strong complexation of metals onto the biochar surface. However, biochar has a limited effect to stabilize arsenic in soil. In our previous researches, the application of biochar to arsenic-contaminated soil increased the release of As from soil to pore solution. In particular, transport of As by biochar is closely related to the dissolved organic matter (DOM) released from biochar and iron oxide on the soil surface.[1] Thus, the way to control effectively the DOM-Fe complexes and Fe redox chemistry is required to lower the As mobility in the biochar application. Calcium peroxide (CaO_2), one of the oxygen releasing compounds (ORCs), can slowly decompose and continuously liberate oxygen (O_2). The application of CaO_2 can inhibit leaching of As due to preventing the reduction of Fe by inducing oxidizing condition. Moreover, Ca^{2+} produced by CaO_2 dissolution can form the low solubility Ca-As precipitates.[2] However, no definitive study has been given to the use of calcium peroxide in the mobility of As and correlations with biochar. Besides, even though the potential of CaO_2 was proved, the concern of increasing pH by produced $Ca(OH)_2$ after CaO_2 dissolution steadily emerged.[3] Therefore, pH control is a key factor to be solved for a suitable CaO_2 application. The primary goal of this study was to investigate the effect of CaO_2 on As mobility in biochar-amended soil. Herein, we hypothesized that the CaO_2 would decrease As releasing by biochar, and encapsulated CaO_2 could control pH than CaO_2 powder. To prove the hypothesis, rice straw biochar pyrolyzed at 500℃ and synthesized nano CaO_2 particles were applied to As-contaminated soil. Besides, encapsulated CaO_2 using alginate was evaluated on the ability of pH control through the comparison of CaO_2 powder.

Keywords: Biochar; oxygen releasing compound (ORC); Calcium peroxide; As mobility

Acknowledgment: This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (grant number: 2019R1A4A1027795) and partially supported by Korea Ministry of Environment(MOE) as Knowledge-based environmental service(Waste to energy) Human resource development Project(YL-WE-18-002).

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S14-12

Treatment of Cesium-contaminated soil through extraction − selective adsorption process

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Currently, most nuclear power plants around the world are old, and the decommissioning of nuclear power plants is one of the most challenging issues. The decommissioning nuclear power plants are required to reduce the volume of radioactive waste for the final disposal in the special facilities. Among the various radionuclides produced in nuclear power plants, cesium(Cs) has a relatively long half-life(30.2yr) and high water solubility, thus it is highly mobile and remains in the ecosystem for a long time, especially in the soil system due to the high affinity with the clay minerals. Since Cs is adsorbed on the soil surface strongly, it needs huge costs for treatment and final disposal. Extraction is a simple and cost-effective way to separate Cs from the soil and a preponderate step to remediate and reduce the volume of the target. Zeolite is an aluminosilicate mineral and used as an adsorbent due to its pore structure and surface charge. Cesium could be adsorbed onto zeolite through adsorption and cation exchange. However, in the presence of other competitive cations(K^+, Ca^{2+}, $NH4^+$) used in the extraction step, the adsorption selectivity of Cs on zeolite should be secured. Thus, in this study, we propose the "Extraction – Selective adsorption" process as a method to treat Cs-contaminated soil at the site remediation stage. Extractants and selectivity on zeolite on various experimental conditions were evaluated to minimize the volume of radioactive wastes.

Keywords: Cesium, Extraction, Selective adsorption, Zeolite

Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education(grant number: 2018R1A2B6004284), and Korea Ministry of Environment(MOE) as Knowledge-based environmental service(Waste to energy) Human resource development Project.

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ICHMET 2020

20th International Conference on
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Session 15

Adsorption of heavy metals on biomaterials

S15-1

Methylene Blue Removal from Aqueous Solutions by Different Types of Standard Biochars: Evaluation of Process Variables

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Methylene blue (MB) is one of the most commonly used industrial dyes. Since MB is not easily degradable, it is generally not removed from wastewater by conventional treatments. Given the abundance of surface functional groups and the well-developed porous structure, biochar has been shown to be a promising adsorbent for organic pollutants. In this study, biochars derived of rice husk, oil seed rape straw, wheat straw, *miscanthus* straw and soft wood, obtained at two different pyrolysis temperatures (550 °C and 700 °C), were subjected to the determination of the point of zero charge (PZC) using the salt addition method. Rice husk (RH) and soft wood biochars (SWP) have been found to be suitable adsorbents for cationic dyes such as MB because of their PZC values, scoring lower than the others. Adsorption of methylene blue (MB) from aqueous solutions by rice husk and soft wood biochars was evaluated under different experimental conditions. Initial sorption experiments revealed a better performance of the rice husk biochar, allowing the exclusion of the soft wood biochar as candidate adsorbent for MB. Optimized operating conditions were obtained by investigating the effects of the adsorbent dosage, the solution's pH and the adsorbate's initial concentration by two levels of factorial experimental design method. pH effect was considered insignificant in the studied range (7–9). The adsorbent dosage and MB initial concentration are not important as main effects alone, but their interaction is crucial for achieving high removal rates. For both biochars, RH550 and RH700, the interaction of these parameters is positive. Ecotoxicological studies showed that both RH550 and RH700 biochars are promising alternatives for the treatment of MB-contaminated wastewaters, particularly the RH700, reaching 0.16 mg L^{-1} final MB concentration. This value is significantly lower than the median effective concentration for 48h of exposition to *Daphnia similis* (EC_{50} 0.77 mg L^{-1}).

Keywords: biochar, point of zero charge, methylene blue, factorial design, adsorption

S15-2

Preparation of HPCs for Removal of Antibiotics from Water and the Adsorption Properties

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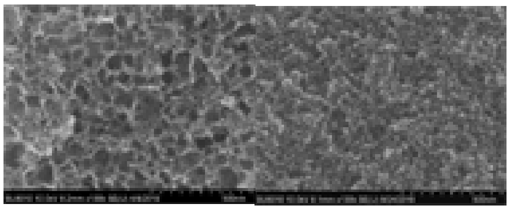
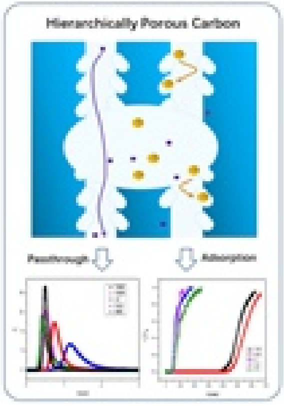
Pharmaceutical antibiotics have recently become emerging environmental contaminants. To enhance the removal efficiency of antibiotics in aqueous solution, hierarchically porous carbons (HPCs) with designed porous patterns are synthesized by template method and used as adsorbents in this study, and the role of their porous geometry in the adsorption dynamics are explored. The hierarchically porous frames of HPCs are clearly prepared. The THPC have similar 50-100 nm cellular macropores that are densely arranged to form the porous networks and the inner walls of macropores show fully microporous structures; the DHPC show stripe-like mesopores 5-8 nm width and micropores can be clearly identified on the walls of the stripes. THPC and DHPC exhibit remarkably superior adsorption performances to tetracycline and tylosin than those of commercial activated carbon (AC) with similar surface area, especially in column mode adsorption. The effective treatment capacities of the HPC-columns remain 8-10 times those of the AC-columns for the removal of tetracycline and 4-6 times for the removal of tylosin. The meso- and macropores in the porous frame of HPCs benefit the Knudsen diffusion coefficient due to the decrease in the collision frequency of the molecules on the pore walls. The mass transfer rates of the carbon-based columns present the order of THPC > DHPC > AC. DHPC exhibits better performance for the adsorption of tetracycline, while THPC is the superior adsorbent for the adsorption of tylosin. The micropores linking to the meso/macropores of the HPCs may induce micro turbulence when the solution flows through the pores, and thus intensifying the mass transfer and adsorption affinity.





Keywords: hierarchically porous carbons, porous geometry, adsorption, antibiotic

S15-3

Application of microalgal-based materials for the removal of hexavalent chromium from water

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According to World Health Organization (WHO), the maximum permissible concentration of hexavalent chromium (Cr(VI)) in drinking water is 0.05 mg/L. The removal of this highly toxic heavy metal from contaminated water is mandatory due to its serious negative effects on animals and humans health. In this study, different microalgal-based materials including living cells of *Scenedesmus quadricauda*, microalgal pellets (wet microalgal biomass), microalgal powder (dried microalgae biomass), chemically modified biomass, and microalgal biochars were investigated for the remove Cr(VI) from water. Among the tested materials, microalgal biochar (2 g/L) showed the highest removal efficiency (100%) of 1, 5 and 10 mg/L Cr(VI) from water. Langmuir model was fitted well with the equilibrium data and the estimated adsorption capacities were found to be 23.98, 25.19 and 24.27 mg/g at 5, 22 and 35 °C, respectively. Kinetic modelling revealed that the pseudo second order model is the best fitted model to experimental data. Desorption efficiency of Cr(VI) from saturated microalgal biochar was observed as 59.41% using 0.1 M NaOH. More than 97% of desorbed Cr(VI) was recovered by barium chloride in less than 10 min. The findings of this study showed that the removal and recovery of Cr(VI) from contaminated water by non-living microalga materials is more efficient than living cells.

Keywords: Hexavalent chromium (Cr(VI)), Microalgae, Removal, Desorption, Recovery

ICHMET 2020

20th International Conference on
Heavy Metals in the Environment

Session 16

Metals/metalloids in sediment-water systems

S16-1

Nano-oxides immobilize Cd, Pb and Zn in mine spoils and contaminated soils and facilitate plant growth

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Chemical stabilization of toxic elements in contaminated soils using natural or synthesized amendments is an inexpensive in-situ remediation method. Effectiveness of synthesized nano-oxides in immobilizing toxic elements in acidic mine spoil (chat) and contaminated soil, has not been studied extensively. The potential of three nano-oxides; i.e., Fe_3O_4 (Fe-O), Al_2O_3 (Al-O) and TiO_2 (Ti-O), for stabilizing Cd, Pb, and Zn in chat and contaminated soil was investigated using adsorption studies and a greenhouse experiment. A monometal adsorption study was conducted for Cd, Pb, and Zn with Fe-O, Al-O and Ti-O, separately. A greenhouse pot experiment was conducted with a sorghum (*Sorghum bicolor* L. Moench). Chat and soil were amended with Fe-O, Al-O and Ti-O nano oxides at two rates (50, and 100 g kg^{-1}) and available metals were compared against a non-amended control. The chat was mixed with compost and and CaO to adjust pH before addition of oxides. Sorghum seeds were sown, and leachates were collected twice per week from plant emergence to harvest at the maturity. Chat contaminated with Cd, Pb and Zn at 84, 1583, and 6154 mg kg^{-1}, respectively and soil at 15,1260 and 3082 mg kg^{-1}, respectively. Adsorption isotherms were conformed to the Langmuir linear form with sorption maxima of 838 to 2333 mg kg^{-1} for Cd, 8333 to 12,632 mg kg^{-1} for Pb and 904 to 10,000 mg kg^{-1} for Zn for all three nano-oxides. Leachates collected from the study showed Al-O significantly reduced Cd, Pb and Zn followed by Ti-O and Fe-O. Nano-oxides of Al-O and Ti-O significantly decreased plant tissue Cd and Zn concentrations as compared to unamended controls in chat and soil, Fe-O being the least effective, among the three. Nano-oxides reduced 28% (Fe-O) to 87% (Ti-O) Cd and 14% (Fe-O) to 85% (Al-O) Zn in plant tissues compared with unamended chat. Concentrations of Pb in plant tissues were very low in all treatments including controls. Available Cd and Zn extracted from chat and soils after harvest showed significant reduction in Al-O and Ti-O treatments. Significant relationships were observed between Cd in plant tissue with available Cd (r=0.87) and plant-Zn with available Zn (r=0.79). No significant difference was observed between two amendment rates, indicating 50 g kg^{-1} as effective as 100 g kg^{-1}. All three tested nano-oxides were effective in immobilizing Cd, Pb and Zn in chat and soils, Al-O and Ti-O being more effective than Fe-O.

Key words: bioavailability, heavy metals, mine spoils, nanoscale oxides, stabilization

S16-2

Sustainable revitalization of river by instream filtering system

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Since the rapid urban development, storm-water pollution has become a significant problem in Hong Kong, which not only affects the river and coastal environments, but also creates odor and visual problems. The King Yip Street Nullah in Kwun Tong is suffering from the stormwater pollution problem. The roughing filter, a type of gravel filtration, is selected as one of the potential stormwater treatment approaches for improving the water quality in the river. This study provided fundamental information of water quality characteristics of the river, preliminary analysis of the filter performance, and recommendation for the further development of filter design used in the pilot study in the King Yip Street Nullah. Firstly, a baseline analysis of water quality was conducted between the King Yip Street Nullah and two major local rivers in Hong Kong (the Kai Tak Nullah and Shing Mun River). Results show that suspended solid and Escherichia coli are two major pollutants of concern in the King Yip Street Nullah, while Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) may become problematic during dry season. Then, in view of the site limitation and high flow rate of the King Yip Street Nullah, the in-stream filter system was designed with four horizontal-flow rock filters working in parallel with a sand trap in front of each filter. Field test demonstrated that the sand traps screened a lot of sandy materials during the site trial period especially after rainfall event. In 1st round of field test, the filter modules could screen the sand effectively but were clogged in short time frame. The filter design should be enhanced with the use of larger gravel size (> 50 mm). In 2nd and 3rd rounds of field test, rock size of 50-120 mm had the best performance. The particle size distribution of the removed sand suggested that the filters were most capable of removing sand with particle size larger than 1.0mm. The in-stream filters were also capable of removing total organic carbon (TOC) from the river. Therefore, the filter system could be promising solution for the stormwater pollution.

Keywords: Sustainable revitalization; Instream filtering system; Stormwater pollution; Suspended solid contamination.

S16-3

Dynamic process and coupling mechanism recognition between heavy metals and sulfide in sediments using DGT technique in Yellow River Estuary

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Dynamic process and coupling mechanism recognition between heavy metals and sulfide in sediment pore water are important to improve the water quality of overlying water. In this work, vertical profiles of fluxes of dissolved sulfide and heavy metals (Pb, Cr, Cu, Zn and Cd) in sediment pore water were investigated by the Diffusive Gradients in Thin films technique (DGT). The study area included intertidal *common seepweed herb*, *phragmites communis,* bulrush zones and a channel mouth around the Yellow River Estuary (Dongying, China). Vertical fluxes of sulfide and heavy metals in different kinds of intertidal sediments showed great variations, indicating that sulfide accumulation closely related to redox conditions of sediments, anoxic and anaerobic conditions contributed to sulfide accumulation due to sulfate reduction. For the heavy metals, results indicated that plants affected dynamic releases or fluxes, implying that intertidal plants showed different pathways in metal accumulation and internal transportation. Furthermore, vertical fluxes of sulfide and heavy metals presented a negative correlation with depth in each case, indicating heavy metal release was partly controlled by accumulated sulfide in sediments.

Keywords: Sediments; Heavy metals; DGT; Sulfide; Yellow River Estuary

S16-4

Zinc pollution in zones dominated by algae and submerged macrophytes in Lake Taihu

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Zinc (Zn) contamination in lake zones dominated by algae and macrophytes in Lake Taihu was analyzed through diffusive gradient in thin films (DGT) and dialysis (HR-Peeper) methods. It was found that in both zones Zn contamination varied by season. In July and October, dissolved Zn was present in high concentrations, and in July, high concentrations of labile Zn were found in sediments. In July, reductive dissolutions of Fe/Mn oxides likely played a key role in the release of Zn, which was confirmed by both zones having the lowest percentage of the reducible fraction of Zn in July. Complexation of dissolved organic matter (DOM) with Zn may be responsible for the observed increase in the dissolved Zn concentration in October. This conclusion was supported by noting that October had the highest percentages of Zn-DOM complexes (25.3% and 34.4%) in the algae- and macrophytes-dominated zones, respectively. However, in January, low dissolved and labile Zn contents were observed in sediments in the two zones, suggesting that the decrease of Zn in sediments was caused by the adsorption of Fe/Mn oxides.

Keywords: Lake sediments, Algal blooms, Submerged macrophytes, Zinc pollution, High-resolution techniques

S16-5

Assessing remobilization characteristics of arsenic (As) in tributary sediment cores in the largest reservoir, China

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The environmental impact of the Three Gorges Reservoir (TGR) in China has raised widespread concern especially in relation to metal pollution. The diffusive gradient in thin films (DGT) technology was applied to investigate arsenic (As) remobilization in sediment cores collected from the main stream and a tributary in the TGR during July 2015. The results showed that the horizontal and vertical distributions of C_{DGT}-As varied among the four sampling sites. For the same DGT probe, the horizontal distributions of C_{DGT}-As (0-6 mm, 6-12 mm, 12-18 mm) exhibited similarity in the overlying water and different tendencies in the sediment profiles; the vertical variations of C_{DGT}-As showed different mobilization tendencies. Moreover, the mobility patterns of As in the sediment profile showed the diffusion potential of As from the deep sediment to the surface sediment and overlying water were in the order of MX-2 < MX-1 < CJ < MX-3. In addition, similar distribution characteristics and correlation analysis showed that the mechanisms of As mobility was associated with Fe and Mn. The results also showed that sulphide and As were simultaneous remobilization in the tributary sediment core in the TGR.

Keywords: Arsenic, Sediment cores, Tributaries, Three Gorges Reservoir, Diffusive gradients in thin films (DGT)

S16-6

A new DGT technique comprised in a hybrid sensor for the simultaneous high resolution 2-D imaging of sulfides, metallic cations, oxyanions and dissolved oxygen

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Diffusive gradients in thin films technique (DGT) coupled to inductively coupled plasma mass spectrometry (LA-ICP-MS) is used to provide 2-D chemical imaging of multielements at submillimeter scale. In this study, a new DGT (HR-ZCA DGT) was developed for two-dimension (2-D) chemical imaging of sulfides, metallic cations and oxyanions (Cd, Co, Fe, Cu, Mn, Ni, Pb, Zn, As, Cr, Mo, Sb, Se, V, P and W) simultaneously using LA-ICP-MS analysis. AgI and zirconium oxide (Zr-oxide) deposited sequentially on a preformed Chelex-100 resin gel to form a new binding gel. The measured mass of each element (except for S) agreed well with the theoretical predication, which validated the use of the HR-ZCA gel for DGT measurement. Good linear relationship (R^2>0.99) between mass accumulation of the 17 elements on the binding gel and corresponding standardized laser ablation signals indicated the feasibility of LA-ICP-MS analysis. In addition, to evaluate the dynamics of multielements and O_2 in sediments, a hybrid sensor comprising the new DGT binding gel overlying an O_2 planar optrode was deployed in sediment cores. Results showed that local hotspots can be shown in the 2-D distribution images while cannot be shown in the 1-D distribution images. It is undoubtedly that the hybrid sensor helps to improve our understanding of sediment geochemistry.

Keywords: Oxyanion, Metallic Cation, Sulfide, Diffusive gradients in thin films, Planar optrode

S16-7

Isotopic signature of the lead fallout from Notre-Dame de Paris fire: implication for urban contamination assessment

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On the night of April 15th to 16th 2019, a fire destroyed large parts of the roof of Notre-Dame de Paris (ND), France. The spire, covered with lead sheets, was the first to be struck by the flames. Then the fire reached the roof, also covered with lead. The temperatures reached (>600°C) led to the melting of this metal but also to the emissions of lead-containing particles forming a yellow plume. The dust from these fumes fell to the ground in and around the cathedral and some was further carried away in the plume of smoke, thus questioning the potential contribution of the fire to the Parisian pollution. As part of our work on the history of the metal contamination in the Seine basin, we have characterized different lead sources by their lead radiogenic isotope ratios. A large quantity of lead dating from the end of the 19th century is stored in Parisian infrastructure. We were also able to assess the contribution of lead from additives to gasoline (banned in 2000). Over the centuries, the different lead sources have been amalgamated, forming what we have called "urban lead", a pervasive signature in the Parisian area. So far, the signature of the lead sheets on the roof of ND, renewed at least twice after its first implementation in the early 13th c., has been identified using fire-formed dust samples collected inside the cathedral. Lead samples from medieval monuments (e.g., Sainte Chapelle, Paris), coeval to Notre-Dame were also collected and analyzed to determine medieval lead signatures and evaluate the recycling rate in ND roof for 18th and 19th c. works. Moreover, large quantities of water were used to extinguish the fire and, in the following months, to evacuate lead-contaminated dust from around the cathedral. As the domestic water and rainwater used in Paris are collected in a unitary system, all these wastewaters were sent to the Seine-Aval treatment station. In the days and weeks following the fire, we collected various environmental samples: outdoor atmospheric particles and indoor dust, total wet fallout, Seine River sediment, sludge from wastewater. We can now put the results of the measurements of the lead stable isotopes ratios in perspective with the data already acquired for the Seine basin and finally trace the ND signal propagation in the Parisian environment.

Keywords: Lead, urban pollution, medieval period, 19th century, historical monuments.

Lead roof of Notre-Dame de Paris, France, before the April 2019 fire. (credit: A. Timbert)

S16-8

Quantification of spatial and temporal variations in antimony fluxes originating from urban areas: a nested catchments study

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While antimony (Sb) is not quite a new pollutant, its increasing uses have resulted in raising concern about its potential health and environmental impacts leading to its addition to the priority pollutants list by the US Environmental Protection Agency. Since 1999, a large set of Sb concentrations data has been collected for the different compartments of the critical zone (air, soils, river water and waste waters) of the Seine River basin (64600 km², France), which is characterised by a long-term, intense and diversified anthropogenic metal contamination. The results showed significant and overspread increases of Sb concentration in soils and river water. Currently, at the scale of the Seine basin, the diffuse atmospheric fluxes (14 T y^{-1}) entering the critical zone dominate the inputs, while the punctual sources (treated wastewaters and combined sewer overflows) are significantly lower (~1 T y^{-1}). Mapping of the soil contamination suggests that Sb accumulates in the urban soils and in the vicinity of roads. These conclusions are supported by the results of a recent study conducted in the urban sub-catchment of the Orge River (900 km², Seine basin) characterised by a sharp up to downstream urbanisation trend, showing that annual Sb exports by the river is two times higher than the inputs from the atmosphere at the scale of this urban watershed. This study aimed at disclosing the impacts of the hydrology and land use on Sb behavior and fluxes. Most of the Sb is carried by the dissolved phase, but unlike Cu, Zn and Pb, whose concentrations are increasing with urbanization, the Sb concentrations in the dissolved phase remained stable across the entire Orge River catchment and indicated the absence of significant inputs of dissolved Sb from urban areas. In contrast, the increase of particulate Sb linked to urbanization was more significant than for the other urban metals. Continuous urban runoff resulting from frequent rainfall events appeared to be the main source of Sb delivered to the Orge River in the particulate form. Consequently, urban runoff might act as a source of Sb, and the possible desorption of Sb from contaminated particles should be assessed to evaluate the risk linked to anthropogenic particulate Sb inputs to urban and peri-urban rivers.

Keywords: antimony, river, urban, metal fluxes, catchment.

S16-9

Thallium pollution in sediments response to consecutive water seasons in Three Gorges Reservoir using geochemical baseline concentrations

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The Three Gorges Reservoir (TGR) is the world's largest hydrological project. However, the response of thallium (Tl) in TGR sediments to reservoir operation remains highly uncertain. Here, we investigated the pollution characteristics of Tl in TGR sediments during five consecutive water seasons. Geochemical baseline concentrations (GBCs) were used to distinguish the anthropogenic input of Tl and to quantitatively estimate the Tl anthropogenic contribution in TGR sediments. The results showed that average Tl concentrations in TGR sediments was 0.72 ± 0.14 mg/kg (ranging from 0.26 to 1.07 mg/kg) during five consecutive water seasons. The average Tl content in tributary sediment was higher than that in mainstream sediment. In the mainstream, Tl in TGR sediments showed the accumulation tendency from the upstream to downstream. Additionally, the temporal variation revealed that the mean value of Tl in TGR sediment in the dry season was higher than that in the wet season during 2015 to 2016. Furthermore, the average GBCs of Tl (0.71 mg/kg) was higher than background values (BVs) in the Yangtze River sediments. Using the GBCs of different water seasons to calculate the anthropogenic input of Tl in the TGR, the average contribution of anthropogenic input was found to be approximate 6.43% (2.81%–9.12%). The assessment results by two different methods (geo-accumulation index and potential ecological risk index) using GBCs as the BVs, indicating that TGR sediments were at "uncontaminated" level and close to the "low ecological risk", respectively. Comparing to the GBC of Tl, the assessment of Tl pollution in TGR using BVs in the Yangtze sediments may be over-evaluated. This study is beneficial for assessing Tl pollution in TGR sediments response to consecutive water seasons and estimating the anthropogenic contribution of Tl in sediment using GBCs.

Keywords: Thallium, Sediments, Three Gorges Reservoir, Geochemical baseline, Consecutive water seasons, Pollution assessment

S16-10

Nitrogen and phosphorus in overlying waters affect the migration and transformation of sedimental heavy metals

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Excessive nutrients and heavy metals in aquatic ecosystems are the main factors for eutrophication and multiple contaminations. However, the interaction mechanisms between heavy metals in sediments and nutrients in overlying water are still unclear. In this work, the effects of nitrogen (ammonium and nitrate) and phosphate in overlying waters on environmental behaviors of heavy metals (Cd, Cr and Cu) in coastal river sediments were investigated. Fresh estuarine sediments and artificial seawater were conducted in simulation experiments (60 d). Furthermore, sterilization and non-sterilization were performed to identify the biological and/or abiological effluences. The results indicated that the releases of heavy metals from sediments increased with increase of nitrogen in the overlying water, while decreased with phosphate increase. This phenomenon mainly related to the formation of metal phosphate precipitation (based on component analysis). Moreover, the exchangeable fraction contents of heavy metals in sediments were positively correlated with the nitrogen in the overlying water, but negatively correlated with the phosphate. For the unsterilized treatment, the total organic carbon (TOC) in the overlying water decreased with nitrogen increase, and great variations of heavy metal fractions were observed. However, in the sterilized treatment, TOC and heavy metal fractions presented stable values correspondingly, indicating that the nitrogen input enhance the fraction variations of heavy metals in sediment through microorganism activity. This study provides an insight theoretical basis for studying the coupling mechanism between heavy metals and nutrients.

Keywords: sediments, nitrogen, phosphorus, heavy metals

S16-11

Lead contamination in sediments in the past 20 years: A challenge for China

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Lead (Pb) contamination was recognized in China early in the 1920s. However, the response of Pb contamination in sediments to China's rapid economic and social development remains uncertain to date. We conducted a literature review of over 1000 articles from 1990 to 2016 and the first national-scale survey of Pb contamination in China. A literature review showed that available research in China focused on the economically highly developed river basins, including the Pearl River Basin (PRB), Yellow River Basin (YRB), and Yangtze River Basin (YtRB), whereas those in the less developed southeastern, southwestern, and northwestern river basins received limited attention. The YtRB and YRB had higher Pb contamination levels than other basins, corresponding with the rapid economic development in those regions. However, the less economically developed river basins in the southeastern and northwestern regions of China were also contaminated by Pb. Analysis of 146 studies in the PRB, YRB, and YtRB revealed that Pb contamination in PRB sediments showed a tendency to improve over time, whereas that from the YtRB exhibited a tendency to worsen. For the YRB, there was a slight increase from 1990 to 2006 and a decreasing trend from 2007 to 2014. The overall temporal trend in Pb levels in PRB and YRB sediments corresponded with that of the Pb discharged in wastewater in the surrounding cities, indicating that industrial wastewater discharge was possibly one of the main anthropogenic sources of Pb in those sediments. For the YtRB, the increasing trend in Pb concentrations was related to the considerably high atmospheric Pb emissions in the surrounding cities and its geographical characteristics. These findings suggested that China should develop systematic and consistent approaches for monitoring Pb contents in sediments and adopt a regional economic development policy focusing on pollution prevention.

Keywords: Lead (Pb); Sediments; China; River basins; Temporal and spatial variations

S16-12

Valorisation of heavy metal contaminated land by industrial hemp for fiber production

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Large areas of contaminated land can be found in Europe. These lands, mostly degraded due to former industrial activities, cannot be used for food production. Since the debate between food versus non-food production is gaining more attention, the need to utilize such sites is growing. Hemp is an emerging raw material in the eco-building and textile industries and can tolerate stress from heavy metals (HMs) and can accumulate these in its tissues. Therefore, the current research aimed to investigate the fate of HMs in the phytoremediation process using hemp. A pot experiment was set up with 6 hemp cultivars on a Cd, Pb and Zn contaminated soil originating from agricultural land nearby the former mettalurgic industry Metaleurop in the North of France. Weight, stem length and heavy metal (HM) concentration in the above-ground plant parts (leaves – shives – fibers) were analysed. The cultivar "Santhica 70" showed the highest weight and stem length. Cd accumulation in the different plant parts was the highest in "CS" and "Santhica 70" and the lowest in "USO31". Fibers of almost all cultivars had the highest Cd concentrations of all plant comparments, except for USO31 and Santhica 70, where Cd concentrations were similar in the different plant parts. Pb and Zn concentrations followed the trend leaves > shives > fibers for all cultivars. USO31 had the highest Pb accumulation, while "DS" had the lowest for the leaves, fibers and in the total plant and "Bialobreskie" had the lowest for the shives. Zn accumulation was the highest in CS and Santhica 70 and the lowest in Bialobrieskie and DS. HM accumulation in a specific plant part thus depended on the HM and the cultivar. In frame of the investigation, the HM concentrations in the hemp fibers were compared to the legal thresholds for textile products. Cd and Pb were far below the threshold limits, while Zn is not mentioned as a target contaminant in the list. This suggests that hemp fibers grown on contaminated land could be used to produce safe and clean textile products. Further research will be performed to analyse whether the extractable part of HMs meet the legal thresholds as well. In addition, legal thresholds in other industries, such as the eco-construction industry, will be compared to the HM concentrations found in the shives. If metals can be extracted from the soil into the hemp plant and safe products can be made from the hemp biomass, marginal land could be used for the production of safe raw material from hemp while remediating the soil.

Keywords: industrial hemp, phytoremediaton, heavy metals

ICHMET 2020
20th International Conference on
Heavy Metals in the Environment

Poster presentations

PP-01

The mechanism of cadmium sorption by Sulphur-modified wheat straw biochar and its application cadmium-contaminated soil

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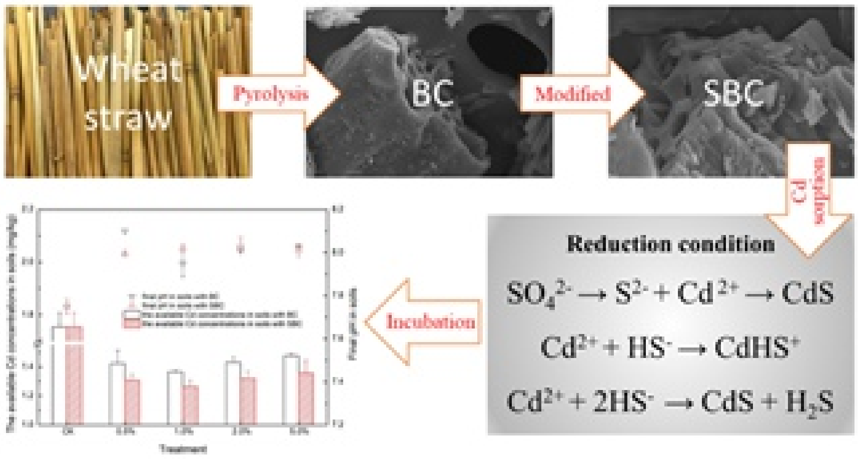
Cadmium (Cd) pollution in soils has received considerable research attention globally, and sulphur-modified biochar (SBC) could combine the advantages of biochar and the sulphur element for Cd remediation. Biochar from agricultural waste is feasible, which has a low preparation cost. However, there are few studies regarding the effects of the sulphur modification of biochar on the Cd immobilization mechanism. This study aimed to research the Cd immobilization mechanism of pristine wheat straw biochar (BC) and sulphur-modified biochar (SBC), and the Cd immobilization effects of BC and SBC in Cd-contaminated soils. Elemental and SEM analysis confirmed that sulphur was successfully loaded on the pristine biochar. XPS analysis confirmed that there was a considerable discrepancy between adsorption mechanisms of Cd on BC and SBC. In particular, cadmium sorption on BC was due to $Cd(OH)_2$ and $CdCO_3$ precipitation formation and interaction with carbonyl and carboxyl groups, whereas on SBC, sorption was mainly due to CdS and $CdHS^+$ formation and interaction with organic sulphide. In the incubation experiment, SBC and BC additions increased pH value and also reduced the available Cd concentrations in the soil. Compared with the control, the contents of available Cd in soil were significantly decreased by 15.86% ~ 22.10% and 22.72% ~ 27.90%, following treatments with BC and SBC, respectively.

Key words: Cadmium; Soil; sulphur-modified biochar; Immobilization mechanism



PP-02

Selective uranium extraction from salt lake brine by amidoximated *Saccharomyces cerevisiae*

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Uranium concentration in salt lake brines is tens even thousands times higher than seawater, which makes salt lake brine being another ideal resource for uranium. However, the content of salt lake brine is very complicate, a large amount of K, Na, Ca, Mg elements coexisting with uranium. Hence, only sorbent with high uranium selectivity can be well used in uranium extraction from salt lake brine. To enhance the selectivity of *Saccharomyces cerevisiae* for uranium, amidoximation of the biomass was performed. –CN groups was firstly grafted on the biomass surface by radical induced grafting reaction (PAN-B), followed by converting nitrile (–CN) groups to amidoxime (–C(NH_2)NOH) groups through reaction with free hydroxylamine (amidoximation). Amidoximated *S. cerevisiae* (PAO-B) can be obtained through these two steps. The effect of solution pH, extraction time, initial uranium concentration and ion strength on uranium sorption by amdoximated *S. cerevisiae* was studied in detail and optimum uranium sorption condition was confirmed. Desorption experiment was also performed and the corresponding results showed that amidoximation did not decrease the uranium sorption capacity of the biomass and the amidoximated *S. cerevisiae*couldbe used at least three times with little loss of uranium uptake capacity. Trace uranium extraction from real salt lake brine samples were conducted, and 75% of uranium in the salt lake brine samples was successful absorbed by amidoximated biomass while hardly any uranium was absorbed by raw biomass. Hence, amidoximation can obviously enhance the uranium selectivity of the biomass and amidoximated *S. cerevisiae*has the potential to selectively extract traceuranium ions from salt lake brine.

Keywords: Amidoximation; Uranium; Selectivity; Biosorption; Salt lake brines

PP-03

Sorption of lead by Clanis bilineata larvae skin-derived biochars

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Clanis bilineata larva skin (CBLS), a new residue from the food industry, was first used to produce biochars by pyrolysis at 300 °C (CBLS300) and 700 °C (CBLS700), respectively, for Pb immobilization. The sorption isotherms and immobilization mechanisms of Pb on two biochars were investigated. CBLS700 exhibited more high-efficiency in sorption of Pb than CBLS300 due to the predicted maximum sorption capacity of CBLS700 (77.52 mg/g) was larger than that of CBLS300 (49.02 mg/g). Synchrotron-based microfocused X-ray fluorescence analysis exhibited the co-distribution of Pb and P in the sorption product of CBLS700 rather than CBLS300. Microfocused X-ray absorption near-edge structure analysis highlighted the significance of organic ligand in the biochar for Pb immobilization due to both sorption products have organic complexed Pb. Moreover, 25% of total Pb was present as hydrocerussite on CBLS300 but partially transformed into stable hydroxylpyromorphite on CBLS700 (~ 21%), which was in accordance with the analysis of scanning electron microscopy coupled with energy disperse spectra. Additionally, addition of CBLS700 was more effective in reducing the leachable Pb in shooting range soil than that of CBLS300. These results strongly suggested the potential application of the new biochar (CBLS700) for the remediation of Pb-contaminated soils.

Keywords: Biochar, lead, sorption, synchrotron-based mechanism

PP-04

Adsorption of Zn in Aqueous Solutions Using Starfish (*Asterina Pectinifera*) Biochar

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Zinc is one of the heavy metals that is an essential element for humans. However, excessive intake of zinc interferes with the adsorption of copper that leads to a copper deficiency and causes anemia, hallucinations, and nausea. Starfish are an omnivorous species that can be very destructive to ocean ecosystems. This study investigated the adsorption of zinc from an aqueous solution using starfish (*Asterina Pectinifera*) derived biochar. The starfish biochar (Non air condition starfish, NACSF) was produced at 500℃ and this temperature was achieved by increasing the temperature by 7°C/min. 500oC was maintained for 2 hours in anaerobic conditions. The NACSF was characterized by XRD, XRF, elemental analyzer, and FT-IR. Also, batch-tests were conducted with a 100ml Zn solution in flasks where the pH was adjusted to 3. The concentration of Zn ranged between 10mg/L and 500mg/L and 0.1g NACSF was used in each sample to evaluate adsorption capacity. After the batch-test, the solution samples were analyzed with ICP-OES for evaluating the adsorption characteristics and capacity of Zinc. SEM-EDX tests were conducted to observe the surface of the residue of the NACSF after the batch-tests. As a result, the adsorption of Zinc on the NACSF was satisfied in the Langmuir equation and the maximum adsorption capacity was measured at 200mg/g. In addition, the SEM-EDX results revealed that Zinc was adsorbed on the surface of NACSF. Thus, NACSF could be an effective and eco-friendly adsorbent for aqueous solutions contaminated by Zinc.

Keywords: starfish, biochar, adsorption, Zinc

PP-05

Arsenic$_{(V)}$ removal using the mine waste-derived adsorbent

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Arsenic is toxic elements in drinking water that are often found in Asian developing countries in recent years. The objective of the present work is to remove As$_{(V)}$ from water using the adsorbent prepared using the mine waste (YD), which contains Fe, Al, and other elements. The performance of YD adsorbent was compared with the commercial adsorbent, Granular ferric hydroxide (GFH). The YD and GFH were characterized by using a scanning electron microscope (SEM), Energy-Dispersive X-ray spectroscopy (EDS), X-ray fluorescence spectrometers (XRF), X-ray diffraction (XRD), and Brunauer Emmet Teller (BET) surface area analyzer. The maximum adsorption capacity of YD was determined as 49.74 mg/g, which is higher than that of GFH (29.07mg/g). The adsorption kinetics data were fitted to pseudo first-order and pseudo second-order rate equation. The faster As(V) uptake kinetics of YD than GFH were attributed to their large pore volume and mesoporous nature. The Freundlich isotherm models were fitted well for YD adsorbents. Furthermore, the continuous column test with real acid mine drainage was conducted to verify the practical applicability. The column could be operated more than 5,800 bed volumes without a breakthrough. Therefore, it is concluded that the YD would be highly efficient and economical adsorbent because it was made by recycling mine sludge to reduce the amounts of wastes.

Keywords: arsenic removal, arsenate, granular ferric hydroxide, mine waste adsorbent

Acknowledgment: This work is supported by a National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP; Ministry of Science, ICT, & Future Planning) (No. NRF-2020R1C1C1003428)

PP-06

Oxidation Effects of Biochar Surface on Cadmium and Chromium Sorption and Phytotoxicity

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Currently biochar has been used to remove pollutants or to reduce toxicity for reclamation of polluted water and soil. Compared with organic compounds, limited information in sorption of inorganic and metal ion by biochar was available. The predominant mechanism for sorption of heavy metal ions by biochar may be the electrostatic interactions metal cations and negatively charged functional groups. In the present study, two biochar samples were oxidized to change their surface functional groups and then used to evaluate the oxidation effects on biochar sorption of cadmium (Cd) and chromium (Cr). One was a sugarcane biochar (SBC), which was produced from sugarcane bagasse by combusting at 350°C for 1.5 h. The other is a bamboo biochar (BBC) was produced with a traditional kiln at 900°C. The biochar samples were passed through a 10-mesh sieve, then were packed in polyethylene begs and embedded into soil under the waster regime of field capacity. The oxidation treatments were conducted for the different periods of 1, 3, 6, 9, 12, and 24 months, respectively. After oxidation treatment, chemical properties (e.g. pH, CEC, point of zero charge (PZC), and surface functional groups) and FTIR spectra of SBC and BBC were measured; sorption isotherms of Cd^{2+} and $Cr_2O_7^{2-}$ for them were obtained by using the batch method. Also, a pot experiment of wheat seedlings was carried out. The different levels of Cd^{2+} (5 µM and 20 µM) and $Cr_2O_7^{2-}$ (0.2 mM and 0.4 mM) were added in the pots with the biochar-amended quartz sands, respectively. After 3 weeks growing, root elongation and plant height of wheat seedlings and metal concentrations in plant were measured. In results, the pHs and PZCs of SBC and BBC were decreased due to the oxidation treatments and the amounts of acid functional groups and CECs were increased. Moreover, CEC and acid functional group were increased more obviously on SBC than those on BBC. According to the FTIR spectra, compared with BBC's surface, SBC's surface contained more carboxylic and aromatic groups. The changes of the functional groups could enhance more sorption of Cd and Cr ions on SBC. And the result of the pot experiment showed that the toxicities of Cd and Cr to wheat seedling were reduced more significantly due to SBC amendment.

Keywords: black carbon, sorption isotherm, carbon sequestration, heavy metals, FTIR

PP-07

Porphyrin-based metal-organic frameworks as low-temperature NO_2 adsorbent

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Nitrogen dioxide (NO_2) is a criteria air pollutant that bring huge damage to the environment and people's health. The emission of NO_2 into the atmosphere contributes to the formation of photochemical smog, fine particulate matter ($PM_{2.5}$), acid rain, as well as many human diseases [1]. The development of effective techniques to mitigate NO_2 emission is therefore urgent and sought-after. Although the selective catalytic reduction (SCR) exhibits high efficiency in NO_2 conversion at high temperatures (250-600 ^{o}C) and has been widely used in industry [2], it does not work for the abatement of ambient NO_2 emission. Gas adsorption by solid adsorbents is a promising approach for NO_2 capture at mild conditions. Some porous solid adsorbents, such as silica, carbon materials, zeolites and metal-organic frameworks (MOFs) and their composites, have been attempted for ambient NO_2 capture [3]. However, as NO_2 is a highly reactive, oxidizing, and corrosive gas, it's challenging to develop the adsorbents that simultaneously show high NO_2 capacity, high selectivity, and good regenerability in real cases. In this work, we successfully developed one type of porphyrin-based metal-organic frameworks (Al-PMOF) as low-temperature NO_2 adsorbent. The NO_2 capture ability was tuned by changing the atom-isolated transition metals (TMs) in porphyrin ring. The NO_2 breakthrough experiments indicated the Al-PMOF with inserted nickel (Al-PMOF(Ni)) showed the highest NO_2 adsorption capacity of 2.30 mmol/g (1000ppm NO_2/Helium, detection limit: 20 ppm NO_2) at room temperature (Fig. 1). *In-situ* diffuse reflectance infrared fourier transform spectroscopy (*in situ*-DRIFTS) and synchrotron X-ray diffraction experiments were conducted to determine the adsorption mechanism. NO_2 would partially transform into N_2O_4 in the framework of adsorbents, and both of the two molecules could interact with Al-node by hydrogen bonding and inserted TMs via π-backbonding. The potential of Al-PMOF(Ni) as efficient adsorbent for ambient NO_2 abatement would provide a new avenue to mitigate NO_2 emission.

Keywords: NO_2 removal, adsorption, MOFs

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PP-08

A systematic analysis of standard biochars for the removal of ions from wastewater

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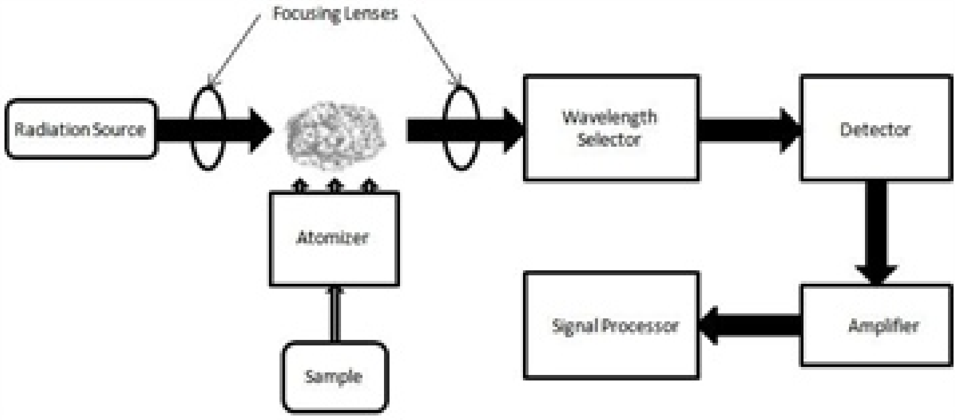
UKBRC produce a set of standard biochars, which are manufactured to precise specifications and are reproducible on an industrial scale. This study characterised these biochars with regards to particle properties (BET, zeta potential and particle density) and adsorption isotherms of a typical cation (copper II) and anion (chloride) in an aqueous solution over a range of pH. The dynamics of the adsorption was also examined. A flame Atomic Absorption Spectrometer (AAS) will be used to measure the copper concentration at parts per million. The data from this study will be useful in the design of wastewater treatment systems associated with a variety of industries, including mining, oil extraction, food and drink and desalination.

Keywords: biochar; ion adsorption; water treatment



PP-09

UV-Clicked Multithiol Functionalized Graphene Bio-Sponge for Heavy Metal Ions Adsorption

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Heavy metals pollution in water remains an unsolved environmental problem pressing for the development of efficient water purification technologies. This work presents the green modification of a bio-sponge for heavy metals adsorption consisting of alginate bio-polymeric network encapsulated with magnetic reduced graphene oxide (mrGO) and functionalized with multithiol precursor via photoinitiated thiol-ene click chemistry. The multithiol functionalized graphene bio-sponge (SH-Graphene bio-sponge) is well-engineered in the structural and surface aspects to possess bountiful micropores, oxygen functionalities and high density of sulfur-containing groups (10.2 at % S) with high binding affinity towards Cd and Pb ions. SH-functionalized graphene bio-sponge showed outstanding adsorption capacity for Pb (II): 101.01 and Cd (II): 102.99 mg/g, outperformed commercial and literature reported adsorbents in highly competitive selectivity studies using co-existing heavy metal ions (Cu, Co, Pb and Cd) spiked-sea water. The multithiol modified bio-sponge also showcased an excellent stability and reusability feature with only 0.015 mg/L Pb (II) detected, meeting the strict US EPA maximum contaminant level (MCL) for lead, after five repeating adsorption-desorption cycles using mixed heavy metal ions solution and acidic eluent. The outcomes from this work contribute valuable and promising solution towards the development of scalable, energy-efficient and sustainable adsorbents for efficient remediation of heavy metals in water.

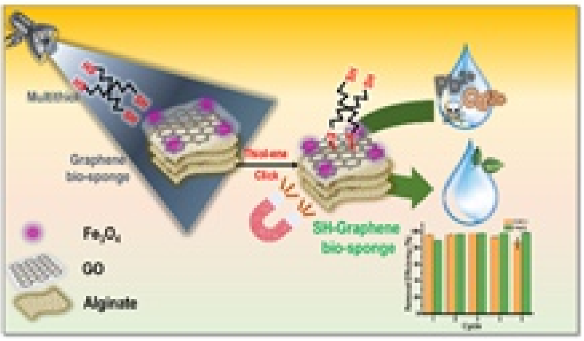

Fig.1. Schematic diagram of the fabrication of SH-Graphene bio-sponge for removal of heavy metal ions, Pb (II) and Cd (II), from the water.

Keywords: multithiol functionalized graphene composites, photoinitiated, thiol-ene click, green chemistry, water treatment

PP-10

Polyethylene imine modified hydrochar adsorption for heavy metals removal from aqueous solution

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An adsorbent hydrochar was synthesized from corn cobs and modified with polyethylene imine (PEI). The hydrochars before and after modification were characterized by scanning electron microscopy, Fourier transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), and thermogravimetric analysis. FTIR and XPS revealed that the PEI was grafted onto the hydrochar via ether and imine bonds formed with glutaraldehyde. The maximum adsorption capacities for Cr(VI) (33.663 mg/g) and Ni(II) (29.059 mg/g) on the modified hydrochars were 365% and 43.7% higher, respectively, than those on the unmodified hydrochar. A pseudo-second-order model described the adsorption of Ni(II) and Cr(VI) on all the adsorbents. The adsorption of Cr(VI) was endothermic, spontaneous, increased disorder, and obeyed the Langmuir model. By contrast, the adsorption of Ni(II) was exothermic, spontaneous, decreased disorder, and obeyed the Freundlich model. XPS confirmed that the adsorption sites and mechanisms for Ni(II) and Cr(VI) on the modified hydrochars were different.

Keywords: Hydrochar, Chromium, Nickel, Polyethylene imine, Adsorption

PP-11

Experimental Study on Mercury Removal and Regeneration Characteristics of Elemental Sulfur-Modified Activated Carbon

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In this study, thermal sulfur-loading methods were used to modify elemental sulfur in commercial activated carbon and then used to remove mercury from simulated coal-fired flue gas. The effects of the sulfur loading method and S/AC mass ratio on the mercury removal performance of an adsorbent were investigated, and the optimal conditions for the preparation of the adsorbent were determined. Various universal techniques (including Brunauer-Emmett-Teller measurement, X-ray fluorescence analysis, X-ray diffraction analysis, transmission electron microscopy, and thermogravimetric analysis) were used to characterize the physicochemical properties of the samples. The results obtained show that the adsorbents with the prepared under the best conditions namely, 5%-AC, showed high performance, and the Hg^0 breakthrough rate was lower than 8.58% at 150℃. By comparing the mercury adsorbent before and after adsorption, changes in the activated carbon-carrying sulfur sorbent surface morphology and elemental composition were observed. The decrease in oxygen and sulfur content of the deactivated adsorbent is one of the reasons for its deactivation. From the desorption curve of the saturated sample of adsorbent after adsorption, the adsorbent regeneration process was determined. The mercury removal rates of the adsorbents were 80.08%, 81.39%, 79.22%, and 72.83% after four regeneration cycles. Hence, the modified activated carbon thermal loaded with elemental sulfur showed excellent adsorbent regeneration characteristics and can be considered a promising mercury regeneration adsorbent for various applications.

Keywords: Mercury adsorption, Thermal regeneration, Sulfur-loaded activated carbon, Sulfur-containing compounds

PP-12

Incorporation of liquid manure and 7 types of food waste biochar for aided-phytostabilization and their impact on arsenic bioavailability and ammonia emissions in arsenic contaminated soil

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In Korea, after the opening of agricultural products in the 1990s, the amount of fruit imports began to increase rapidly due to the expansion of the market opening level following the expansion of the Free Trade Agreement (FTA). In recent years, not only the quantitative expansion of imported fruits, but also the diversification of imported fruits has progressed greatly, and the fruit import line is also diversifying. This trend inevitably causes the generation of various imported fruit wastes, especially fruit peels, and there is a high demand for research on its treatment. For effective use, in this study, after converting 7 types food waste (coffee, tea, banana, grape, orange, melon, and grape fruit) to biochar, they were applied to be used as an amendment for arsenic contaminated soil. In addition, swine liquid manure was additionally treated to provide nutrients for phytostabilization. Through this experimental design, we expect to achieve both the effect of reducing the bioavailability of arsenic and the effect of reducing the amount of ammonia emission from liquid manure through the adsorption capacity of biochar. Lab scale experiment was conducted and dynamic capture-camber system (DCS) was also utilized for the quantification of emitted ammonia after liquid fertilizer spreading into arsenic contaminated soil. Chemical and biological assessments were also conducted to confirm the changes in arsenic bioavailability.

Keywords: Ammonia emission, bioavailability, biochar, food waste, phytoremediation

PP-13

Short-Term and Long-Term Effect of Biochar on Pb Immobilization in Soils

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Biochar has been known as an effective material for heavy metal immobilization in soils. The immobilization capacity of standard biochar in short and long term experiments is evaluated in this study. Soil was taken near the Tancheon Mine in Korea and contaminated with heavy metal including high concentration of Pb. Ten kinds of standard biochar (MSP550/700, OSR550/700, RH550/700, SWP550/700, WSP550/700) which produced from UKBRC were selected as the adsorbent of Pb. 50 g of Pb contaminated soils were treated with 2.5% biochar and incubated at room temperature. The incubation was performed in short and long term, for 21days and 7months, respectively. To compare the soil property and Pb immobilization capacity of the period of time, pH, electrical conductivity (EC), and available Pb were analysed. As a result, the pH value tended to decrease in long term incubation, and it decreased the most in SWP700 treated soil from pH 6.20 to pH 5.38. On the other hand, the EC value tended to increase through the incubation period with the largest increase in WSP550, from 0.10 dS/m to 0.18 dS/m. The purpose of this study is to investigate the change in Pb immobilization capacity at different incubation periods.

Keywords: heavy metal immobilization, Pb contaminated soil, standard biochar

PP-15

Artificial ageing of amended soils and its impact on Cd speciation in soil solution

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Cadmium (Cd) is a non-essential trace element naturally occurring in soils. Cd contents mainly depend on the bedrock but also the potential anthropogenic inputs. In Ireland, geogenic Cd contents are particularly elevated in some agricultural areas (Fay et al., 2007) which is of great concern for the quality of the crops grown of these soils. Indeed, regulations of trace elements, and especially Cd, are starting to become stricter to reduce exposure to these elements. The uptake of Cd by crops is mainly influenced by its availability in the soil and most specifically by the initial free Cd concentrations in the soil solution and the soil buffer power (Lin et al., 2016). Among the numerous existing methods to reduce Cd uptake, the spreading of organic amendments has been shown quite efficient and probably the most suitable method for agronomic purposes. However, the amelioration mechanisms are not fully understood and more specifically the longevity of their effectiveness after application.

Hence, this study aimed at following the evolution of the soil solution composition over time with a focus on the Cd speciation. In order to simulate ageing and speed it up, the experiments were conducted in growth chambers with controlled conditions and the soils were submitted to drying/rewetting cycles. Three organic amendments, poultry manure, spent mushroom compost and brown bin waste, were studied in two different soils, known to have high geogenic Cd content. Homogenised 2mm-sieved soil and amendment were mixed at 2 agronomically feasible rates and then incubated for 2 weeks prior to the artificial ageing procedure. Soil solution has been periodically sampled using rhizons and chemically characterized in order to assess Cd speciation.

Keywords: Cadmium, speciation, soil solution, ageing, organic amendments

PP-16

Inkjet-printed prussian blue-decorated magnetic microparticles for the enhanced removal of cesium from water.

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Facile synthesis approach to fabricating prussian blue (PB)-decorated magnetic poly(vinyl alcohol)(PVA) microparticles was designed for the magnetic removal of cesium with enhanced Cs adsorption kinetics and capacity. The PB decorated magnetic PVA microparticles were generated via two-step sequential procedures using a piezoelectric ejection process, followed by chemical precipitation of PB in magnetic PVA microparticles. The magnetic PVA microparticles could be achieved by physical crosslinking of PVA with in-situ formed iron oxide nanoparticles by reductive reaction of the iron ion in basic solution during the piezoelectric ejection process. Then, the PB was decorated on the magnetic PVA microparticles by chemical precipitation reaction between ferric ion and potassium hexacyanoferrated ion. Compared with the previously reported millimetre-sized magnetic PVA beads fabricated by drop-wide method [1,2], our micron-sized magnetic PVA microparticles containing PB showed the enhanced Cs adsorption property due to the increased specific surface area of the particles. Additionally, the PB decorated magnetic PVA microparticles were recovered from wasted water within a few minute under magnetic fields, indicating their great potential for magnetic separation. Therefore, the convenient fabrication method and improved Cs removal ability of PB decorated magnetic PVA microparticles demonstrated the great potential for practical application in the decontamination of Cs-contaminated water.

Keywords: magnetic hydrogel microparticle, Cesium removal, Prussian blue, piezoelectric ejection process

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PP-17

Assessment of High-Pressure Soil Washing Techniques for Pb and Zn Contaminated Soils

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There are many soil remediation techniques for soils contaminated by heavy metals, such as soil washing, stabilization/solidification, thermal desorption and land farming. However, these techniques have unavoidable drawbacks because of non-environmentally friendly process requirements and cost prohibitive time constraints due to the use of chemical reagents and time intensive processes. Therefore, the authors explored another water-based soil treatment for Pb and Zn contaminated soils using high-pressure soil washing techniques. Soil particle-size distribution, pH, CEC, and concentration of Pb and Zn in the soils were examined in order to obtain the soil characteristics before washing. The high-pressure soil washing results revealed that Pb and Zn concentrations were reduced by 93.4% and 61.7%, respectively. These results satisfied the Korean Soil Contamination Warning Standards for residential areas. Also, sequential extraction and SEM-EDX analysis were conducted to compare the soil characteristics after applying these techniques. Based on all these results, high-pressure soil washing could be an applicable remediation technique at sites contaminated by heavy metals.

Keywords: high-pressure soil washing, heavy metals, Pb, Zn, remediation

PP-18

Exogenous nitric oxide promotes cadmium tolerance and accumulation in a high cadmium-accumulating rice (*Oryza saliva L.*) line by promoting polysaccharide synthesis of root cell wall

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Exogenous nitric oxide (NO) has been confirmed to enhance plants tolerance under heavy metal stress, while the role for regulating cadmium (Cd) tolerance and accumulation in a high-Cd-accumulating rice line is still poorly understood. In the present work, a hydroponic experiment was conducted, the effects of sodium nitroprusside (SNP) as a NO donor additive on plant growth, antioxidant enzyme activities and Cd accumulation in root cell wall polysaccharides of a high Cd-accumulating rice line (Lu527-8)were investigated, with a control of a common rice line (Lu 527-4). Results showed that exogenous NO alleviate root elongation and growth inhibition induced by Cd stress through enhancing catalase (CAT) and superoxide dismutase (SOD) activities, and endogenous NO concentration, which in Lu527-8 were higher than that of Lu527-4. Exogenous NO increased Cd concentration in root, Cd concentrations in soluble fraction and cell wall were significantly increased, which in organelle fraction was decreased. Root cell wall was further decomposed and separated polysaccharide into pectin, cellulose and hemicellulose (HC). Under co-treatment of Cd and 50 μM SNP, Cd concentrations of HC1 and pectin, as well as uronic acid of pectin and HC1 increased more obviously in Lu527-8 than Lu527-4. Hence, an increase in synthesis of pectin and HC1 were likely involved in enhancing root cell wall retention of Cd and reducing Cd toxicity in high Cd-accumulating rice line Lu527-8 by exogenous NO.

Keywords: nitric oxide, rice (Oryza saliva L.), cadmium tolerance and accumulation, cell wall polysaccharide

PP-20

Selective separation of clay in Cs contaminated soil using flotation with hydrophobic silica nanoparticles

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Recent studies have shown that cesium(Cs) in the contaminated Fukushima soil have accumulated within the top 5 cm of the soil profile due to the strong affinity of clay for Cs. To reduce the radioactivity of Cs-contaminated soil, the separation of fine particles (clay and silt) is desirable because fine particles contain the high concentration of Cs. In this study, fine particles were separated from contaminated soils by using commercially available hydrophobic hydrophobic silica nanoparticles. After mixing the contaminated soil and hydrophobic silica nanoparticles without water, distilled water was added to the column to selectively float and separate the fine particles. The particle size distribution was performed before and after separation process. Based on the results, the separation efficiency of fine particles was over 99%. We found the optimal condition for the ratio of mixed soil and fumed silica nanoparticles to be 0.04:1 mass ratio (g-hydrophobic silica nanoparticles per g-soil). Separation test conditions were flow rate 1.25 L/min, aeration holding time was 10 min. These results showed that fine particles were successfully separated using flotation with hydrophobic silica nanoparticles. We expect to reduce the amount of radioactive soil by separating high-contaminated fine particles (clay and silt) using flotation with hydrophobic silica.

Keywords: Cesium, Clay, Fumed nanosilica, Hydrophobic, Flotation, Separation

PP-21

Citric acid assisted phytoremediation of lead and mercury by *Taifa Latifolia* L.

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Chelate-assisted phytoremediation via-phytoextraction by high biomass producing macrophyte plants improves heavy metals removal from polluted environments. *Typha latifolia* L. commonly known as cattail, a wetland plant has great potential for phytoextraaction. The present study investigated the effects of Lead (Pb) and Mercury (Hg) on physiology and biochemistry of plant, Pb and Hg uptake in *T. latifolia* with and without citric acid (CA) amendment. The uniform seedlings of *T. latifolia* were treated with various concentrations in the hydroponics as: Pb and Hg (1, 2 and 5 mM) each alone and/or with CA (5 mM). After four weeks of treatments, the results revealed that Pb and Hg significantly reduced the plant agronomic traits as compare to non-treated plants. The addition of CA restored the plant physiology and enhanced the antioxidant enzymes activities to overcome Pb and Hg induced oxidative damage and electrolyte leakage. Our results depicted that Pb and Hg uptake and accumulation by *T. latifolia* was dose depend however, the addition of CA further increased the concentration and accumulation of Pb and Hg by up to 22 & 35% Pb and 72 & 40% Hg in roots, 25 & 26% Pb and 85 & 60% Hg in stems and 22 & 15 Pb and 100 & 58% Hg in leaves respectively compared to Pb and Hg treated only plants. The results also revealed that *T. latifolia* showed greater tolerance towards Hg and accumulated higher Hg in all parts compared with Pb. The present study also suggested that CA has both potentials as chelating agent and growth regulator under heavy metal stress.

Keywords: Antioxidant Enzymes, Accumulation, Chelator, oxidative stress, macrophyte, Physiology

PP-22

Vanadium Biogeochemistry and Bioremediation

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Mineral smelting and fossil fuel combustion activities release large amount of vanadium into geological environment, resulting environmental pollution. The toxicity of vanadium increases with the increase of valence. Pentavalent vanadium [V(V)] is the most toxic. This study reveals biogeochemical processes of vanadium in Panzhihua, China, world-famous for vanadium storage and production. Vanadium distributions and microbial responses are studied. Soil at smelting site is the most heavily contaminated, and its vanadium content is multiple times higher than background value. Vanadium has strong impacts on microbial communities. The migration and transformation of vanadium is significantly affected by co-existing electron donors (organics, hydrogen and methane), electron acceptors (nitrate, sulfate) and pollutants (chromate, pentachlorophenol). Indigenous microorganism can successfully bioreduce V(V) to less toxic and insoluble tetravalent vanadium [V(IV)], achieving in situ remediation. Supplementary solid inorganic electron electrons as elemental sulfur and zero-valent iron can support this biotransformation efficiently. Bioelectrochemical intensification can further improve the effectiveness. This study is helpful to reveal biogeochemical fates of vanadium in smelting site and provides promising alternatives to successful remediation.

Keywords: Vanadium; Biogeochemistry; Heavy metal; Bioremediation

PP-23

Selective Sorbents for the In Situ Immobilization of ^{129}I, ^{99}Tc and other Contaminants

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Long-lived isotopes like iodine-129 (^{129}I) and technetium-99 (^{99}Tc) are often the primary risk drivers at nuclear waste facilities. As high yield fission products, both isotopes are generally found together in nuclear waste materials, and both display very limited adsorption to common soil minerals. Both ^{129}I and ^{99}Tc have multiple redox states and can form sparingly soluble compounds under certain conditions. The primary objective of the current study was to evaluate a range selective sorbents for the in situ immobilization of ^{129}I and ^{99}Tc (and uranium, U), in an effort to potentially enhance the natural attenuation capacity. The test sorbents can be placed in one of two general categories: metal-based and carbon-based sorbents. The metal-based sorbents included iron oxides, and Porous Iron Composite (PIC) materials that have proven to be superior to other zero valent iron (ZVI) for immobilizing ^{99}Tc and U, especially in the presence of alternate electron acceptors. Zero valent iron was also included for comparison. The two new PICs incorporated copper (Cu; PIC-Cu) and silver (Ag-PIC-Ag) into the materials, as a means of increasing the effectiveness at immobilizing I- through precipitation. The carbon-based sorbents included several Granular Activated Carbon (GAC) sources, including two that also incorporated Cu and Ag, i.e., GAC-Cu and GAC-Ag. The sorbents were evaluated in an extensive series of batch studies that also evaluated the ability of the materials to immobilize I in the form of iodide (I^-, -1), iodate (IO_3^-, +5), and organic iodine compounds (iodoanilin). Rhenium was used as a non-radioactive analogue for 99Tc. Of the materials tested, only one of the PIC-Cu and one of the GACs was effective for in the sorption of all the test contaminants.

Keywords: radionuclides, iodine, technetium, zero valent iron

PP-24

Ionic surfactant enhancement of clay properties from the basement complex soil of Southwestern Nigeria for heavy metals adsorption in aqueous medium

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Surface properties of raw kaolinite clay collected from Ire-Ekiti, South-western Nigeria, was improved through modification by using eco-friendly anionic surfactant ‘Sodium Dodecyl Sulphate’ (SDS) for the adsorption of heavy metals (Pb^{2+}, Cr^{3+}, Ni^{2+} and Cu^{2+}) from their aqueous solution. This research work was achieved through batch adsorption study. Optimization of adsorption condition like temperature, particle size, concentration, agitation time and pH was performed to investigate the extent of adsorption and applicability of the modified clay. The results obtained showed that equilibrium adsorption was faster for Cu and Pb at 30 and 40 min respectively. Effect of temperature showed that the sorption process of the metals on the SDS modified clay was endothermic. The optimum adsorption was achieved in acidic condition, which showed that the adsorption process involved series of complex mechanisms which include: ion exchange, direct bonding and surface complexation rather than precipitation. Adsorption efficiency of the SDS modified clay for removal of the metal ions was as follow: $Pb^{2+}>Cu^{2+}> Cr^{3+}>Ni^{2+}$ with optimum percentage (%) removal of 98.5, 94.5, 80.3 and 73.8 respectively.

Keywords: adsorbate; adsorption; heavy metals; modification; equilibrium; enhancement.

PP-25

Green and Novel Stabilisation/Solidification of Zn by Metakaolin-Based Geopolymer

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Geopolymer is a type of alternative cementitious materials that comprises a three-dimensionally cross-linked, highly-polymerised and non-crystalline alkali aluminosilicate network. Different from ordinary Portland cement (OPC) system, the role of chemical additives in geopolymer system is not well understood. In this study, we explored the effect of Zn (a known OPC retarder) on geopolymer reaction and investigated immobilisation mechanism of Zn in geopolymer gels. Isothermal calorimetry results showed that substitution of ZnO (20%) significantly hindered geopolymer reaction process, possibly due to the preferential formation of Na/K-Zn phase. X-ray diffraction analyses illustrated that crystalline ZnO completely transformed into amorphous materials after 7-d curing. Nuclear magnetic resonance data further indicated that dissolved Zn^{2+} partially displaced Na^+/K^+ in charge-balancing sites and bonded in geopolymer gels. Based on setting time and leaching tests, K-activated geopolymer had favourable compatibility with Zn during geopolymerisation, whereas Na-activated geopolymer performed an excellent fixation capacity to Zn. Practical experiment demonstrated that metakaolin-based geopolymer is a sustainable and promising compatible material for the stabilisation/solidification of Zn-rich sludge.

Keywords: alkali-activated materials; toxic elements; ion-exchange interaction; green remediation; waste management.

PP-26

An oxidation-modified biochar-based composite amendment significantly enhanced Cd adsorption ability

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A novel engineered biochar with natural alkaline nanoparticle distributed on carbon surfaces within the biochar matrix has been successfully developed as high effectively and low-cost amendment for environmental applications. Three rice straw biochar-based composite amendments modified by oxidation (RFW-A), high temperature (RFW-H), and naturally mixing with fly ash and white marble powder with a mass ratio of 2:1:2 (RFW-P) were prepared and characterized in this work. The characteristics of Cd adsorption by the three biochar-based composite amendments were investigated simultaneously. Compared with the rice straw biochar, RFW-A and RFW-H showed greater porosity and surface area, while RFW-P showed lower porosity. After modification, the three composite amendments presented more functional groups, especially a new band at 3400 cm^{-1} assigned to -OH, and more -C=O and C=C, while less mineral components ($CaCO_3$) and metallic oxide (Fe_2O_3). Both physical and chemical adsorption processes contributed greatly to Cd adsorption by the three composite amendments. The saturated adsorption capacities of Cd by RFW-A, RFW-H, and RFW-P were 30.12 mg g^{-1}, 15.79 mg g^{-1}, 11.50 mg g^{-1}, respectively. Cd adsorption affinity and adsorption rate of RFW-A were greater than those of the rice straw biochar, followed by RFW-H and RFW-P. It proves that RFW-A possesses greater Cd adsorption ability, which was mainly attributed to iron exchange and complexation with oxygen-containing functional groups, thus could be an ideal immobilization agent for the remediation of Cd-contaminated soils or waters.

Keywords: Biochar-based composite amendments, Cd adsorption, Structure characterization, Functional group

PP-27

Insight into the mechanisms involved in the bioremediation of mercury(II)-polluted soil by a novel plant growth promoting strain AN-B15

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Bioremediation using plant growth-promoting bacteria (PGPB) is a cost-effective and eco-friendly strategy for treatment of heavy metal-polluted farmland. However, few studies have evaluated bioremediation potential and promotion of the safe production of crops by the PGPB in mercury (Hg)-polluted soil. In the current study, a plant growth-promoting bacterium AN-B15 was isolated and exploited as a potential bioremediator for Hg-removal and for enabling the safe production of crops. AN-B15 can volatilize the majority of Hg (approximately 65%) and immobilize a small part of Hg (approximately 27%) via mainly the production of β-HgS in the solution. Moreover, reduction of total Hg and exchangeable Hg extracted by diethylenetriaminepentaacetic acid with inoculation of AN-B15 affirmed the feasibility of this dual function of Hg(II) removal and immobilization on the bioremediation of Hg-polluted soil. Furthermore, pot experiments showed that inoculation with AN-B15 can significantly improve growth parameters and antioxidant enzyme activity, and reduce the uptake of Hg in wheat seedlings. Specifically, compared to the treatment with Hg only, inoculation with AN-B15 significantly enhanced root length (127.59%) and shoot length (67.85%), and decreased Hg content in the shoot (85.52%) and Hg content in the root (54.96%) under 20 mg of Hg(II) stress, respectively. Meanwhile, analysis of genome and transcriptome revealed the related molecular bases of Hg(II) volatilization, production of HgS, and plant growth-promoting traits in AN-B15. The genome of strain AN-B15 is a circular chromosome of 6,301,094 bp with 60.15% GC content. Transcriptome analysis identified transcription of the *mer* operon (*merRTPFADE*) at high levels (4.03-7.94 fold) in AN-B15, indicating that the *mer* operon was responsible for the volatilization of Hg(II). Meanwhile, AN-15 contain the genes or operon related to siderophore pyoverdine biosynthesis, indole acetic acid biosynthesis, polylamine spermidine biosynthesis, inorganic phosphate solubilisation, and 1-aminocyclopropane-1-carboxylate deaminase involved in multiple traits of plant growth promotion. Thus, these findings could be conducive to understanding the mechanisms of PGPB responsible for their bioremediation potential and enabling of sustainable safe production of crops in Hg(II)-polluted soil.

Keywords: mercury(II)-polluted soil, bioremediation, Hg biovolatilization, transcriptome

PP-28

Capacitive deionization of uranium (VI) with novel MOF-derived N-doped hierarchical porous carbon electrodes

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With the continuous development of nuclear energy, radioactive metal ions such as ^{235}U have been unduly discharged into the water environment, which bring about a great threat to human health and ecological safety. Based on the electrical double layer capacitance (EDLC) principle to remove ions, capacitive deionization (CDI) started to attract attention for adsorption of U(VI). Due to the high surface area and tuneable pore size, metal-organic frameworks (MOFs) are suitable precursors for constructing high-efficiency carbon electrodes for CDI. Herein, we report a novel N-doped hierarchical porous carbon (NHPC) derived from MOFs as CDI electrode for U(VI) electrosorption. By kinetics-controlled growth of zeolitic imidazolate frameworks-8 (ZIF-8) and polymerization of p-aminophenol and formaldehyde, the as-prepared core-shell ZIF-8@AF are subsequent pyrolysis to obtain NHPC. Specially, the AF shell can serve as a rigid interface to induce a confinement effect, which is benefit for increasing the dwelling time of vaporized Zn, thereby engendering the formation of more mesopores. As shown in Fig. 1(a) and (b), the as-prepared NHPC shows uniform dodecahedron with the size of ~200 nm. N_2 adsorption-desorption isotherms and pore size distributions (PSDs) indicate the abundant mesopores and hierarchical porous structure (Fig. 1(c)), which are beneficial for ions diffusion and charge transport. During the charge process, the anions are adsorbed to anode while cations are attracted to the cathode, thus achieving the removal of target ions (Fig. 1(d)). As expected, NHPC shows excellent adsorption capacity towards UO_2^{2+} (Fig .1(e)) which indicates that NHPC is a promising CDI electrode material for the electrosorption of U(VI) from wastewater. In summary, we have successfully prepared N-doped hierarchical porous carbon (NHPC) derived from MOFs. Due to the large specific surface area and suitable pore structures, NHPC shows good adsorption capacity towards UO_2^{2+}. This work demonstrates the promising prospect of CDI technology for the electrosorption of U(VI) from wastewater.

Keywords: capacitive deionization, metal-organic framework, porous carbon, Uranium (VI)

PP-29

Status, Source of Herb Medicine's Heavy Metal Pollution And Its Control Strategies

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Herb medicine has been obtaining great attention all over the world owing to its excellent performance in chronic diseases' prevention and treatment. However, heavy metal pollution of herb medicine has become an obstacle for its export and wide application. The objective of this study is to overview the status of herb medicine's heavy metal pollution, identify its source and propose control strategies. This study compiled a total of 1,600 data on heavy metal pollution of herb medicine, which were extracted from two database of "Web of Science" and "China National Knowledge Infrastructure (CNKI)". We defined that 883 pieces of data from "CNKI" represent the pollution situation in China and 716 pieces of data from "Web of Science" represent the pollution situation worldwide. Based on the maximum contaminant limit level of five heavy metals (Cd, Cu, Pb, As and Hg) in herb medicine regulated by the Pharmacopoeia of the People's Republic of China (2020), the over-limit ratio of single heavy metal is 13.7% and that of multiple heavy metals are 6.8% in China. The worldwide situation is worse because the over-limit ratio of single heavy metal is 25.1% and that of multiple heavy metals are 7.7%. The trend of herb medicine's heavy metal pollution with time in China could be explained well by the implemented environmental protection policy and fertilizer/pesticide usage policy. We also identified the source of herb medicine's heavy metal pollution in terms of its full-chain production process, including planting, processing, storage and transportation. Planting is the most important source of introducing heavy metals, which might come from the polluted soil, air and irrigated water. Processing might remove heavy metals from herb medicine by the new technology of membrane separation, supercritical CO_2 extraction, microporous resin separation, etc, but also might introduce a new source of heavy metals by addition of additives. The storage and transportation process might introduce new heavy metals from containers. Finally, a series of control strategies will be proposed for the full-chain production process to minimize the heavy metal content in herb medicine. This study provides comprehensive review of herb medicine's heavy metal pollution, including the status assessment, source identification and control strategies.

Keywords: herb medicine, heavy metal, pollution, source, control

PP-30

Comparisons of developmental toxicity of germanium and tellurium in zebrafish (*Danio rerio*) and medaka (*Oryzias latipes*) embryos

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The use of technology-critical elements (TCEs) such as germanium (Ge) and tellurium (Te) has increased rapidly in line with high-tech developments. The TCEs enter aquatic environments owing to the production, usage, and disposal of TCEs and related products and waste. However, the aquatic toxicity of the TCEs is still not well characterized. The purpose of this study is to compare the developmental toxicity of Ge and Te in the embryo-larval stages of two model fish species, namely zebrafish (*Danio rerio*) and medaka (*Oryzias latipes*). Fertilized zebrafish and medaka embryos were randomly distributed into each well of 24-well microplates containing dosing solution prepared in a soft water medium for toxicant exposure. Four concentrations (zebrafish:0.05-20 mg/L; medaka:0.05-40 mg/L) plus one control were used for each tested compound. The plates were covered and incubated at 26 ± 1 °C for 72 h (zebrafish) and 7 days (medaka) respectively. The results showed that heartbeat of zebrafish embryos were significantly reduced with 72h aqueous exposure to Ge concentration (1, 10 and 20 mg/L) as compared to the control groups. The hatching and survival rate of zebrafish embryos were significantly reduced with 72h aqueous exposure to high Ge and Te concentration (20 mg/L) as compared to the control groups. The locomotor activities such as mean velocity and mobility of zebrafish embryos were significantly increased with 120h aqueous exposure to high Ge and Te concentration (20 mg/L) as compared to the control groups. However, developmental toxicity of Ge and Te did not significantly differ in the medaka embryo.as compared to the control group. Overall, developmental toxicity of Ge and Te in the zebrafish embryo was higher than in the medaka embryo. We first reported the embryonic toxicity of TCEs (Ge and Te) in the early life stages of zebrafish and medaka exposed during the embryonic stage. The results will help researchers to evaluate the hazardous risk of TCEs and their effect on the aquatic ecosystem.

PP-31

Bioaccessibility of trace metal(loid)s in urban dust: effect of the type of synthetic body fluid and liquid to solid ratio

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Bioaccessibility of particulate matter-bound trace metal(loid)s instead of total content may better represent the exposure risk of such pollutants in humans. For this purpose, different simulated fluids representing lung and gastric fluids are used in the literature. Gamble’s solution represents the interstitial lung fluid that can contact with particles reaching the lungs after inhalation; however, important differences in the composition of interstitial fluids are found. Artificial lysosomal fluid (ALF) represents the acidic fluid resulting from the attack of macrophages to the particles reaching the alveoli. In addition, coarse particles firstly reaching the upper airways are swallowed toward the digestive system; in this case, gastric fluids are used to solubilize the trace metals contained in these particles. The aim of this work is to study the bioaccessibility of a reference material corresponding to an urban dust (SRM1948a) using synthetic biological fluids commonly used in the literature (Gamble’s, ALF and gastric) and water. Two Gamble’s composition were used (G1 and G2, the latter containing glycine). Since one of the key factors governing the leaching of trace elements from solid particles, mainly at non acidic conditions, is the liquid to solid ratio (L/S), L/S ratios ranging from 500 to 20,000 were used to study the bioaccessibility of urban dust, considering the following metal(loid)s: V, Mn, Fe, Ni, Cu, Zn, As, Cd, Sb and Pb. The results obtained indicate that the bioaccessibility at a L/S ratio of 5,000 is one order of magnitude higher in Gamble (G2) than in Gamble (G1); it is assumed that the presence of glycine in G2 fluid allows the formation of soluble metal complexes. The bioaccessibility of most of the studied metal(loid)s at a L/S ratio of 5,000 is higher in ALF fluid and lower in water, with the exception of V and Ni. The differences between the bioaccessibility obtained in Gamble (G2) and gastric fluids at L/S ratio of 5,000 are not relevant, except for Pb (Gamble (G2) 1.87%, Gastric 54.57%), Cd and Fe. Finally, the study of the effect of the L/S ratio shows that the bioaccessibility in Gamble fluid increases logarithmically when increasing the L/S ratio whilst remains practically constant in gastric and ALF fluids. These results will be considered in the developing of a metal bioaccessibility protocol to be applied to real particulate matter samples (coarse and fine fractions).

Keywords: bioaccessibility, trace metal(loid)s, synthetic body fluids, urban dust

PP-32

Assessments of metal concentration in maternal blood, placenta and umbilical cord blood and their associated pregnancy outcomes

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Heavy metals are ever-presenting environmental pollutants with known toxic properties. To better understand the relationship between prenatal exposure to heavy metals and the risk of adverse pregnancy outcomes (ponderal index, birth weight, head circumference, birth length), it was investigated the status of heavy metals level in Agra (India) region pregnant women population by collecting maternal blood, placental tissue and umbilical cord blood. The heavy metals concentrations were analyzed by inductively coupled plasma-mass spectrometry (ICP-OES). No differences with statistical significance in the aluminium (Al), calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn) the concentrations were observed between the adverse pregnancy outcome group. Analyzed toxic metals such as Al, Ni and Cr were found higher in maternal blood whereas, Cd and Co were found higher in placenta which may be associated with poor pregnancy outcomes. Essential metals such as Fe, Mn, Cu and Mg were found higher in maternal blood whereas Ca and Zn were found higher in placenta. The correlation between birth (birth-weight) and metals was assessed and found non-significant inverse associations. These results indicated that environmental exposure to Pb and Cd may increase the risk of adverse pregnancy outcomes in women of Agra region without occupational exposure.

Keywords: Birth weight, maternal blood, placental tissue, cord blood, and heavy metals.

PP-33

Adsorption of Radioactive Cesium by immobilizing Prussian Blue on Polypropylene non-woven filter

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After the Fukushima nuclear accident in 2011, Cs134 and Cs137 spread over a large area, and restoration work has been ongoing for several years. Research has shown that Prussian Blue is an effective adsorbent with more than 90% absorption rate, so then by immobilizing it on the membrane surface, we could have a superior adsorption material. In this study we aim to confirm immobilizing PB on the Polypropylene non-woven filter that could provide high Cesium adsorption performance. As PP have inert surface property, for having a membrane with high efficiency first need to do surface amendment to prepare the membrane surface. The modification steps concluding O_2 plasma and acrylic acid modification for PP melt-blown filter. After modification, a numerous amount of PB could immobilize on the PP surface. In forward, PB has been synthesis on the membrane in high amount and Cs adsorption has been tested by the prepared filter. Analysis of the filter after Cs adsorption demonstrated a large amount of adsorption and high efficiency even by small size of filter. So, the results indicate that using the new synthesis method of PB on the modified PP filter could increase the amount of PB particles, extending the PB surface for adsorbing, and following this, PB will adsorb Cs in a high percentage. Also, well efficiency in the small size of PP melt blown membrane for adsorbing Cs in an aquatic environment is clearly visible.

Keywords: Cesium, Prussian blue, Polypropylene, Immobilization, Adsorption

Acknowledgment: This study was supported by the Creative Convergence Research Project (CAP-15-07-KICT) of the National Research Council of Science and Technology (NST).

PP-34

Diets and health risks: a new perspective of hazardous heavy metal intake and accumulation in humans

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Hazardous heavy metals and metalloids are classified as non-essential to metabolic and other biological functions. These metals are deleterious in various respects, in which arsenic (As), lead (Pb), cadmium (Cd), and mercury (Hg) are listed as the top 4 dangerous substances by the United States Environmental Protection Agency and the Agency for Toxic Substances and Disease Registry (ATSDR). After being released into the environment, hazardous heavy metals will be biotransformed and bioaccumulated via food chain, thus posing threats to human health. Previous studies have suggested there might be a global geographical pattern of heavy metal contamination in soil-food crop system. However, to our knowledge, no report has been made on the global pattern or testing the global pattern of heavy metals in crop systems across different continents in a single study. Moreover, populations in different regions generally have various diets. Therefore, the global pattern of heavy metal in certain countries will be more complicated in such cases, which have barely been considered. In this report, we presented a case study of the health risks posed by heavy metals via food consumption in populations with different diets, in which samples of rice and wheat in different provinces of China as well as major countries around the globe were collected and the contents of four main heavy metals (i.e., As, Pb, Cd and Hg) in food were measured. Combining diet pattern data from surveys, the intake of these heavy metals was calculated and then health risks were estimated using a thorough health evaluation system.

Keywords: heavy metal, health risk, diet pattern, rice, wheat

PP-35

From the Age of Information Technology to the Age of Psychology − the SUPERESSENTIALITY of Chemical Element Lithium

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Lithium is an element which has been investigated relatively less from analytical, biochemical, molecular genetic and medical health effective point of view; especially considering and with respect to it‘s tremendous and mostly highly beneficial influence on ALL mentally related diseases. Since Cade discovered positive effects of Lithium against manic depressive (bipolar) disorders in 1949, only some highly “speculative” results have entered the scientific scene. A few innovative researchers have found extremely strong effects of Lithium against suicide, dementia, Alzheimer, and other diseases. This paper declared Lithium as an ESSENTIAL element and is introducing the term „SUPER- ESSENTIALITY“ for the element Lithium. Following scientific hypothesis will be given: 1. Depending on their highly specific and therefore highly individual living conditions, ALL people can be described as manic depressive (bipolar) in the broadest sense. 2. There are three subsequent and substantial therapies for ALL mental diseases: a. The patient/human should deal as much as possible POSITIVE influences, which are available for her or him. b. The patient/human should “celebrate” strong information exchanges (communication) with well trained psychiatrist, psychologist, psych- and physiotherapists etc. including the family, friends and other highly trusted persons. c. A Lithium therapy, possibly in combination with other psychopharmaceuticals will be discussed, if 2a and 2b show no positive effects. In respect that humans are entering a psychological age at the moment guided by the former age of information technology the way for humans to move and described above seems to be SUPER-ESSENTIAL, too.

The first part of this talk has been already presented during the Functional Food Conference at Harvard Medical School in Boston during autumn 2019.

PP-36

Co-release potential and human health risk of heavy metals from pipe scales under stagnation conditions of drinking water

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The re-release of heavy metals accumulated in the drinking water distribution system (DWDS) may pose a significant threat to water quality and human health. In this work, the pipe scales in the actual DWDS were collected, and their physicochemical characteristics were investigated by XRF, XRD, XPS, and sequential extraction procedure. The co-release potential of heavy metals under different scale dosage, temperature, and stagnation times was explored by stagnation release tests. Pearson correlation analysis on metal release and human health risk assessment were used to reveal the inter-metal correlation and potential risk of metal release. The results show that the metal release potential under stagnation conditions of water arises primarily from the acid-soluble fraction. The chronic non-carcinogenic risk of soluble metals followed the order: Mn > Fe > Zn > Pb. The risk caused by the soluble metal release can be ignored (HI < 1) under normal stagnation times (within 8 h). The major finding of this work is that Ca and Mn were more labile to release and had a significant linear co-release correlation (scale powder: $R^2 = 0.906$, $p < 0.01$; pipe section: $R^2 = 0.982$, $p < 0.01$), which indicates their co-existence and linear co-release. Ca was recognized as the "major metal" that affected the release of trace metals. The health risk probably increased with the release of Ca, which could also be used as an "indicator" of Mn release.

Keywords: Heavy metal, Release, stagnation, human health risk, drinking water distribution system

PP-37

Cobalt accumulation pattern in immature mice after subchronic exposure to cobalt chloride - relationship with iron homeostasis

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Cobalt (Co) is an essential trace element, environmental pollutant and a hypoxia-mimicking agent. Oral intake of Co supplements and internal exposure through metal-on-metal (MoM) hip implants deliver the highest systemic Co concentrations. The relationship between cobalt exposure and iron (Fe) distribution in the organism remains unclear. The aim of the study was to assess cobalt accumulation and tissue distribution pattern in immature mice after subchronic exposure to cobalt chloride in relation to iron homeostasis. Pregnant mice were exposed to 75 mg/kg b.w. cobalt chloride ($CoCl_2 \times 6H_2O$) with drinking water for 3 days before delivery and treatment continued until postnatal day 30. Age-matched control animals obtained regular tap water. To assess age-specific Co distribution in immature mice, samples were collected at postnatal days 18, 25 and 30. Blood serum, erythrocytes (RBC) and target tissues (liver, kidneys, spleen and muscles) were obtained and subjected to ICP-MS analysis. Subchronic $CoCl_2$ treatment led to a significant time- and age-dependent accumulation of Co in the target tissues in the following pattern: liver>kidney>spleen>serum>muscles>RBC in day 18 Co-exposed mice. In day 25 mice muscles accumulated more Co than the spleen: liver>kidney>muscles>spleen>serum>RBC and in day 30 higher Co concentration was measured in the serum: liver>kidney>muscles>serum>spleen>RBC. Although tissue iron content increased, its pattern distribution remained the same as in the untreated controls: RBC>spleen>kidney/liver>muscles>serum. The results indicate that immature mice are very sensitive to perinatal and early postnatal Co exposure. The altered Fe homeostasis suggests that $CoCl_2$ exerts its toxic effects on tissues indirectly possibly through altered Fe-regulatory protein expression.

Key words: cobalt, iron, target organs, subchronic exposure, immature mice

Acknowledgments: The study was supported by Grants No. DNTS/Russia 02/1/14.06.2018 from the Bulgarian National Science Fund and No. 18-54-18006 from the Russian Foundation for Basic Research.

PP-38

A ROS Defensive Mechanism is Involved in the Rice Response to Indium Stress

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Heavy use of Indium (In) compounds in the manufacturing of semiconductor materials has resulted in their increased concentrations in the soil and groundwater. Information on how In affects the growth of rice plants is still on a rudimentary level. This study aims to characterize the effect of In treatments on the physiology and molecular changes of rice (*Oryza Sativa* L.). Our results displayed that In treatment inhibited the normal growth of rice seedlings, by reducing plant height and root length. To understand the molecular regulation of In transport, accumulation and tolerance in rice, the transcriptome of In-treated rice was compared with that of rice grown under control condition. A total number of 1,858 and 452 Differential Expressed Genes (DEGs) were identified from the roots and shoots respectively, with many of which are involved in the oxidation-reduction process and metal binding functions. In coherence with the molecular findings, 3,3'-Diaminobenzidine (DAB) and Nitro Blue Tetrazolium (NBT) staining generally showed an increased accumulation of hydrogen peroxide (H_2O_2) and superoxide (O^{2-}) in the leaf and root tissues of In-treated plants. A ROS-related defensive mechanism is triggered in rice seedling as an adaptive response to In stress.

Keywords: Indium, *Oryza Sativa* L., rice, abiotic stress, RNA sequencing.

PP-39

Prediction of Cd Concentrations in Wheat Roots by Using Non-linear BLM

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According to geometrical constraints for binding of different cations on biotic ligands to result in alleviation of heavy-metal absorption by plant, an approach of non-linear biotic ligand model (BLM) considering coexistent cations, such as Ca^{2+}, Mg^{2+}, and K^{+}, was proposed for prediction of Cd uptake in wheat root. A hydroponics of wheat seedlings in short-term Cd exposures was conducted for assaying Cd phytotoxicity and absorption by roots. In results, the significant reductions of Cd concentrations in wheat roots were observed due to increasing Ca^{2+}, Mg^{2+}, and K+ activities, respectively, in solution. The alleviation of Cd absorption by the root was pronounced more by increase of Ca^{2+} and K^{+} than by increase of Mg^{2+}. The reduction of the ratios of Cd concentration in root to Cd^{2+} activity in solution was associated with increasing Ca^{2+}, Mg^{2+}, and K^{+} activities and in the non-linear relationships, which may be due to the geometrical constraints for binding on biotic ligands. Thus, the wheat assay was in accordance with the non-linear BLM approach to Cd uptake by root. One could obtain two additional parameters, competition equivalent and stability constant, for the nonlinear BLM to predict the Cd concentrations in root more accurate and precise. That is, the profiles of the geometrical constraint and affinity of Ca^{2+}, Mg^{2+}, and K^{+} binding on wheat root resulting in alleviation of Cd absorption shouldn't be ignored. In conclusion, the findings suggested the non-linear BLM could be used to improve monitoring of heavy metals absorption by plant in a coexistent-cation-specific environment.

Keywords: heavy metal, free ion activity, ion competition, biotic ligand, phyto-availability

PP-40

Modelling Alleviative Effects of Magnesium on Copper-Induced Oxidative Stress in Grapevines

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The aim of this study is to model the alleviation effects of magnesium (Mg) on copper toxicity to grapevines. Root elongation, Mg and Cu accumulation, reactive oxygen species (ROS) production, and antioxidants concentration were examined in grapevines grown in the nutrient solutions with 0, 2, 4, and 8 mM Mg, without or with 15 μM Cu addition. Significant inhibitory effects of the elongation of new roots were observed for grapevines treated with 15 μM Cu. No significant effect was found of root growth with Mg treatments. On the other hand, most of the Cu accumulated in grapevine roots, while the addition of Mg to the treatment containing Cu significantly reduced the Cu contents in roots, stems, and leaves after 3-day exposure. Superoxide dismutase (SOD), catalase (CAT), and malondialdehyde (MDA) were stimulated both in the roots and in the leaves after exposure to Cu for 1 day and 3days; however, hydrogen peroxide (H_2O_2) was induced by Cu only in the roots. Ascorbate peroxidase (APX) was not activated by Cu addition. Moreover, no obvious dose-response relationship was observed between Mg concentration and CAT, APX activity and MDA concentration. On the contrary, SOD activities and H_2O_2 concentrations in the roots were decreased with increasing Mg levels in the nutrient solutions. Based on the concept of damage assessment model, the alleviative effects of Mg on the oxidative stress induced by Cu toxicity in the roots were further characterized by an exponential decay equation. It can be concluded that oxidative stress, compared with root elongation, can be regarded as a more sensitive indicator of Cu toxicity in grapevines. In addition, the alleviative effects of Mg on Cu-induced oxidative effects may be resulted from the reduction of Cu accumulation and translocation in grapevines.

Keywords: antioxidant, damage level, reactive oxygen species, root

PP-41

Potential of trace element accumulation in edible plants using metal accumulation index (MAI) – a case study of southern Poland

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The objective of the study was to determine the potential of edible plants to accumulate trace elements basing on the metal accumulation index (MAI). Edible parts of vegetables, fruits, and cereals were collected in southern Poland precisely from arable soils previously investigated for total and bioavailable contents of trace elements. Investigated soils were fully suitable for edible plant cultivation. The MAI index assesses the simultaneous metal accumulation by each plant. The higher MAI value the higher potential for metal accumulation. Contents of As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Sb, Se, Tl, and Zn in plant samples were analysed using inductively coupled plasma mass spectrometry (ELAN 6100, Perkin Elmer, Waltham, USA). Altogether, 36 species of vegetables (classified as root, tuber, shoot, legume, inflorescence, fruit, leafy, and seed), 21 species of fruits (classified as berry, pome, shell, and stone), and 6 species of cereals (barley, maize, oat, rye, triticale, and wheat) were investigated. Contents of Cr and Se in all plant samples were below limit of quantification, thus they were excluded from further analysis. For the remaining elements the calculated MAI values were in the following ranges: vegetables 1.84–49.9, fruits 0.81–8.82, cereals 2.86–41.4. Ranges of the calculated MAI values for groups of vegetables were as follows (species with the highest MAI value in brackets): root: 2.07–21.9 (parsley), tuber: 2.73–6.26 (garlic), shoot: 7.61 (asparagus), legume: 7.92 (green bean), inflorescence: 2.59–3.56 (broccoli), fruit: 2.06–5.70 (sweet pepper), leafy: 1.84–49.9 (lovage), seed: 2.41–13.5 (pumpkin seeds). Decreasing order of the groups of vegetables according to the mean MAI value was as follows: leaf > legume > root > shoot > seed > tuber > fruit > inflorescence. Ranges of the calculated MAI values for groups of fruits were as follows (species with the highest MAI value in brackets): berry fruits: 0.81–5.40 (gooseberry), pome fruits: 1.20–2.78 (pear), shell fruit (walnut): 8.82, stone fruits: 1.01–6.83 (nectarine). Decreasing order of the groups of fruits according to the mean MAI value was as follows: shell fruit (walnut) > stone fruits > berry fruits > pome fruits. Investigated species of cereals according to the calculated MAI values were decreasingly ordered as follows: oat (41.4) > wheat (40.2) > barley (26.0) > rye (15.9) > triticale (12.3) > maize (2.86). The results revealed that differentiation in trace element accumulation depended on the species, group and part of the plant.

Keywords: heavy metals; vegetables; fruits; cereals; arable soils

PP-42

Heavy metals in Seaweed: a bio-indicator of metals exposure and environmental pollution

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While the consumption of seaweed/seaweed based products is very common in East Asian nations, representing a notable component of daily diets, relatively very few studies have concerned the concentrations of heavy metals in these and potential effects on human health. This study analyses the concentrations of 17 elements in locally resourced seaweed to assess potential non-carcinogenic and carcinogenic risks to human health. The samples were ground, homogenized and quantified using the ICP-OES technique. It has been found that the essential elements K, Ca, Mg, Zn and Na typically show concentrations greater than a number of potentially toxic metals, Cd, Pb, Ag and As included, exceptions being Ni, Cr-IV and Si. Statistical analysis indicates the latter to all have similar origin, with increased concentration of these potentially toxic metals within the marine ecosystem. While the daily estimated intake of most metals are seen to be within the recommended daily dietary allowance level, the non-carcinogenic risk, estimated via the hazard quotient, shows a value greater than unity. This indicates a potential for adverse effects to health via consumption of the seaweed. The carcinogenic risk resulting from non-essential elements, show higher values than the US-EPA reference limit of 10^{-4}. Considering the non-biodegradability of heavy metals and their potential accumulation in seaweed, there is a need for critical examination of metal levels in seaweeds obtained from the studied locations, also for introducing a practice of adsorptive removal of heavy metals in seaweeds via bio-adsorbent techniques.

Keywords: Seaweeds, ICP-OES, Food analysis, Trace elements, Non-carcinogenic & carcinogenic risks.

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Exogenous glutathione promotes cadmium detoxification and retention by regulating various relevant biosynthesis in roots of rice (*Oryza Sativa* L.)

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Cadmium (Cd) is a toxicant for rice and glutathione (GSH) in plants holds vital roles in Cd detoxification. Exogenous GSH can alleviate Cd toxicity, however the underlying regulatory mechanisms is little known. Two independent genotypes, a low Cd-accumulating genotype D62B and a high Cd-accumulating genotype Wujin4B of rice (*Oryza Sativa* L.), were exposed to no Cd (CK), Cd alone (Cd) or exogenous GSH in Cd (CG). By comparative transcriptome of roots, there were 1122 and 505 differentially expressed genes (DEGs) were detected in D62B and Wujin4B exposed to CG compared with Cd, respectively. And the related gene ontology (GO) terms, including DNA binding transcription factor activity, oxidoreductase activity, hydrolase activity and transcription regulator activity, were enriched in both genotypes. Besides, the function of DEGs in response to different stress showed an obvious genotype-specific. Antioxidative defense system responded to Cd stress by GSH metabolism in both genotypes, meanwhile diterpenoid biosynthesis and phenylpropanoid biosynthesis participated in Cd detoxification in cell wall of both genotypes and exogenous GSH further regulated the biosynthesis. Differently, membrane played an irreplaceable role in Cd resistance in D62B and a total of 11 relevant GO terms were enriched in D62B, whereas regulation of metabolism and biosynthesis was more important for Wujin4B. Besides, GSH metabolism responded more exclusively to Cd Stress in D62B by the regulation of *GSTs* and more GSH and phytochelatins synthesized in D62B. Exogenous GSH can regulate a series of metabolism, which benefits Cd detoxification and retention in the roots of rice. And the great capacity of GSH metabolism maybe one of the important specific genetic basis for low Cd-accumulating genotype rice.

Key words: Cadmium, Rice (*Oryza sativa* L.), Transcriptome, Detoxification, Glutathione metabolism

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Chemicals management issues, with emphasis on geochemical cycles of major metal/loids commonly found in food

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"Chemical food safety" is one of the three key global food safety concerns. The other two are "Microbiological hazards" and "Genetically modified food". It is essential to ensure food is safe, in the entire food chain. This is especially in developing countries, which have taken a more rapid pace in development than developed countries, and hence more toxic chemicals are emitted due to industrial activities. Our early project on "Chemicals management issues in developing countries and countries with economy in transition" (sponsored by Global Environment Facility and the United Nation Environmental Program) is to support sound management of chemicals throughout their life-cycle that lead to the minimization of significant adverse effects on human health and the global environment. A series of toxic chemicals are categorized into (1) Process Based (such as electronic-waste, mine waste/drainage, sewage sludge/biosolids for land application; (2) Product Based (such as lead in paint, artificial fertilizer); (3) Effect Based (such as endocrine disruption); (4) Compound/Class Based (such as heavy metals, arsenic, PAHs). Results indicated that metal/loids ranked top of all the chemicals management issues in these countries. The overall aim of this paper is to review the major geochemical and environmental pollutants found in our food items (crops and fish). Examples are cited in the Pearl River Delta (South China), which has undergone a rapid socio-economic change during the past 40 years. Monitoring and assessment of metal/loids, including those generated from geochemical (e.g., arsenic) and environmental (e.g., mercury) sources in the environment and common food items are therefore important. Body (various human tissues) loadings of toxic chemicals and relevant epidemiological data would provide evidence on their health implications. These, together with associated socio-economic loss, can better convince policy makers to formulate, and enforce control policies. Furthermore, the use of scientific input for sustainable coastal management is discussed. This is related to the disposal of dredged sediment into coastal area, with emphasis on the food-chain transfer of metal/loids, which may impose ecological and human health hazards. Chemical management issues are of high priority in our region, in order to combat environmental pollution and to ensure safe and quality food supplies, in line with the recent call for building Guangdong Province, Macau and Hong Kong, into "a role model of high-quality development".

Key words: food-chain transfer; crops; fish; waste recycling; mercury; arsenic

PP-45

Effects of Cadmium and Chromium accumulation in *Pheretima posthuma* (earthworm)

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Industrialization and anthropogenic activities are the major source of heavy metals toxicity that affected soil dwelling animals. When these metals enter in the food chain, produce serious effects on their health. Earthworms are called as the ecosystems engineers as they enhance the soil productivity by mixing the organic matter via their mobility. They can store metals in their bodies. This study was aimed to determine the effects of Cadmium and Chromium on their body mass and appearance while accumulating these metals in one of earthworm species *Pheretima posthuma.* A total of thirty five earthworms were reared in plastic containers for 30 days in a completely randomized block design comprising of five experiments with four treatments and one control for this study. They were provided with chromium sulphate (300, 200mg/kg of soil), cadmium chloride (300, 200mg/kg of soil). At the end of experimental period, flame absorption spectrophotometer was used to analyze the earthworms which showed that earthworms stored chromium in greater concentration (2.81 mg/kg dry weight) as compared to cadmium (1.90 mg/kg of dry weight) available in the soil. Moreover, significant decrease $P>0.05$ in biomass was observed in the treated animals as compared to control.

Keywords: Heavy metals, Toxicity, Accumulation, Biomass

PP-46

Ecotoxicological effects of single and binary mixture of nano-TiO_2 and galaxolide in the radish (*Raphanussativus*)

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Nano-TiO_2 and galaxolide (HHCB) are continuously released into environments due to their wide usage in personal care products. The ecological effects of these chemicals have attracted increasing attention. In this study, the effects of individual and binary mixture of nano-TiO_2 and HHCB in *Raphanussativus* were explored. The indices of growth performance (germination rates, length of root and shoot elongation) and random amplification of polymorphic DNA (RAPD) profiles of DNA damage in the roots of the seedlings, and expressions of genes related to DNA damage, repair, and cell cycle were examined. The results showed that nano-TiO_2 (5-200mg·L^{-1}) did not affect the germination of radish, but HHCB ($\geq$50 mg·L^{-1}) inhibited it. Both nano-$TiO_2$and HHCB caused serve DNA damage including DNA mismatch damage, DNA double-strand breaks and chromosomal damage. Binary mixture exposure showed antagonistic effects and 200 mg·L^{-1} nano-TiO_2 could reduce the genetic toxicity of HHCB to radish. In addition, among all the genes examined, MRE11 and WRKY40 were most sensitive to nano-TiO_2 and HHCB, implying that these two genes can be used as sensitive biomarkers for the exposure to nano-TiO_2 and HHCB in *R. sativus*. This study helps understand the potential risk posed by nano-TiO_2 and HHCB in *R. sativus* in particular and possibly other plants in general.

Keywords: nano-TiO2; HHCB; radish (*Raphanussativus*); DNA damage; biomarker

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The location distribution of pollutants in burst metal pipe in drinking water distribution system

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Microbial corrosion and trace heavy metals accumulation in the metal water supply pipe would aggravate the scale blockage even peeling off, whereafter develop pipeline leakage or burst. Deposits which excavated from three 23-year service period burst pipes, combing advanced microstandard technique and Illumina high-throughput sequencing, the micromorphology, chemical composition and bacterial community were investigated systematically. The results showed that various heavy metals (Al-89%, Cr-62%, Pb-82% and Tl-71%) were accumulated in the cement layer than that in metal scale. Unlined pipes were ruptured at the wall, whereas lining pipes formed scales at the joints then trigger leakage or burst. Dendrogram results demonstrated that V and As, Al and Pb, Fe and Zn were grouped into each cluster with co-competitive adsorption and co-precipitation. Under microbial action, Tl, Ca, Al, Cr, Mn and Cd showed an extremely positive correlation with *Rhodocyclaceae*, *Ferritrophicum*, *Thermodesulfovibrionia*, *Clostridiaceae*, etc. Unlike cement, metal scales were colonized by diverse bacterias, especially corrosion bacterias included Iron oxidizing bacteria, iron reducing bacteria, sulfur oxidizing bacteria, nitrifying bacteria, etc. Health hazard quotient revealed that Tl, V, Mn, and Pb had potential risks to consumers. PICRUSt functional projections indicated that pipeline microbiota was associated with *acid transport and metabolism of amino* and i*norganic ion.* Overall, this study provides valuable information for optimizing pipeline corrosion prevention of different materials, and serves as certain revelation for corrosion pipeline leakage, burst and heavy metals release.

Keywords: Pipe-corrosion scale, Heavy metals, Drinking water distribution system, Microanalysis, Illumina high-throughput sequencing

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Silicon can alleviate the negative effects of soil cadmium pollution on garlic growth, quality, and food safety

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Abstract: Soil heavy metal residues not only produce phytotoxicity, but also pose a serious threat to health once ingested by human body. Garlic, as a world-recognized necessary table food and health care product, can be edible of its bulb, pseudo-stem, young garlic shoot and leaf, which is more risky than other crops. Split-plot experiment was conducted to study the effects of silicon fertilizer on the yield, quality, physiological characteristics, cadmium residues, and edible safety of garlic under cadmium stress. Yield and quality of garlic decreased with the increase of soil cadmium stress, especially the highest yield reduction (Cadmium = 1.2 mg kg^{-1}) reached 16.6%; silicon fertilizer (2.0 g kg^{-1}) could significantly alleviate cadmium stress, and increase the yield of bulbs and young garlic shoot by 21.3% and 63.0%, respectively. Cadmium residues in various organs showed root > bulb > pseudo-stem > leaf > young garlic shoot. Among them, the edible safety of young garlic shoot is higher. At the maximum soil cadmium level (1.2 mg kg^{-1}), the cadmium residues in garlic bulbs exceeded 8.1 times the limit for edible pollutants (China). The application of 2.0 g kg^{-1} silicon fertilizer significantly reduced cadmium residues and kept them within the safe limit. The main mechanisms by which silicon alleviates the toxic effects of soil cadmium on garlic include increasing antioxidant enzyme activity, promoting photosynthesis and fluorescence.

Keywords: Garlic; Soil Cadmium Pollution; Silicon; Product Quality and Safety

PP-49

Characteristics and risk assessment of metal pollution in groundwater and river water in river in a gold mining area

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Recognizing the pollution characteristics and health risks of metals in groundwater and surface water in river in gold mining area are important to human safety. In this study, the samples of groundwater and surface water in Jiehe River were collected, and the single factor index, Nemero index, and US EPA health risk assessment model were employed to the pollution characteristics and health risks of metals (As, Cd, Cu, Hg, and Zn). According to Environmental Quality Standards for Surface Water (EQSSW, GB 3838-2002), most of metal concentrations were within the limits of classes I-III, only the Hg concentration in surface water in site S1 exceeds the limits of class IV of EQSSW. As for groundwater, all metal concentrations were lower than the class V of the Standard for Groundwater Quality (GB/T 14848-2017). Basing on Nemero index, groundwater quality in this study area was destroyed by gold mining, which exhibited to moderate to severe pollution level. In addition, the assessment of potential human health risk revealed that there may have health risk for human. This study contributed an understanding contamination characteristics, and health risk level of metals in groundwater and surface water in river in a gold mining area.

Keywords: gold mining, metal, surface water, groundwater, health risk

PP-50

Removal of arsenic(Ⅴ) from aqueous solutions using iron-loaded ceramsite as an applicable adsorbent

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Adsorption of As(Ⅴ) onto iron-loaded ceramsite adsorbent fabricated from arsenic-contaminated sediments was studied. Batch studies yielded theoretical adsorption capacity for As(Ⅴ) of 10.63 mg g^{-1} at pH=7 condition and demonstrated that the adsorption process was spontaneous and endothermic. The data fitted pseudo-second-order kinetic well suggested chemisorption mainly governed the arsenic adsorption. Further experiments of effect of co-existing anions revealed that phosphate had the greatest adverse impact on As(Ⅴ) adsorption while other anions were insignificant showing possible application. From the regeneration experiment, the iron-loaded adsorbent demonstrated 91%, 86%, and 80% recovered arsenic adsorption capacity in the first, second, and third cycle of the adsorbent showing high regeneration potential. Previous therotical studies have focused on improving adsorption capacity with synthetic arsenic-rich solutions, nevertheless the real water will have more influential factors that deteriorate the adsorption behaviour. Therefore it is of great significance to conduct adsorption experiments with real source. The 100 cm^3 arsenic-rich sediment were placed in the buttom of jar with 200 ml deionized water to simulate the situation of the sediment on the riverbed. Herein, different amount of adsorbent were also introduced to investigate the real adsorption ability. As from Fig. 1(a), with the continueous mixing, the arsenic concentration in blank jar test kept rising dramastically while the jars with adsorbent showed stable arsenic concentration. It was obvious that adding more adsorbent will lead to lower arsenic concentration, but more dosage will result in lower efficiency of the adsorbent (Fig. 1(b)). Therefore, using small amount of iron-loaded ceramsite adsorbent (such as 0.4 g) will achieve better performance and lower the cost of the adsorbent.

Keywords: adsorbent, arsenic-rich sediment; iron

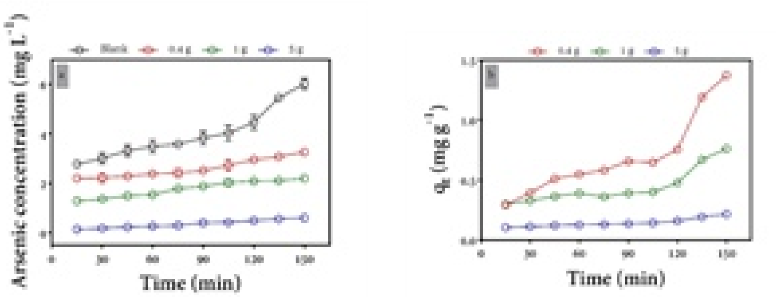

Fig. 1. (a) Adsorption from real arsenic-contaminated sediment leaching and the (b) adsorption capacity at different time.

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Bioavailability and Toxicity Assessments for Long-term Arsenic Contaminated River Sediment with Analytical and Toxicological Methods

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Arsenic (As) contamination in soil, sediment and aquatic ecosystem is an important environmental issue. Currently, much less studies focus on understanding biogeochemical processes of As in the aquatic sediment system and impact of As-contaminated sediment on bioavailability and toxicity of aquatic life. This study first investigates mobility and speciation of As in sediment-water phases for different properties of environmental sediments collected along with Tamsui River basin of Taiwan within 90 days of aging processes after As spiking. Larvae of medaka fish (*Oryzias latipes*) were then exposed to As (III)-contaminated sediment for 14 days with the whole-sediment exposure method to assess the bioavailability and toxicity of sediment As on fish. During the 90-day static aging process for As-contaminated sediment, sediment with lower clay content (CC), organic matter (OM) or cation exchange capacity (CEC) and metal oxides (MO) released higher As contents into overlying water from sediment pore water due to lower As-binding affinity by sediment. During 14 day fish exposure period; however, these weakly-bound labile As fractions were easily flowed out along with daily renewal of overlying water resulting in lower As concentrations in overlying water and lower As body burden in treated fish. In contrast, fish exposed to the As-spiked sediment with higher CC, OM, CEC and MO had higher As body burden because medaka fish can uptake settled sediment particles with strongly bonded As. In addition, sediment As exposure dose-dependently altered antioxidant activities and reduced fish growth. The body weight inhibition rate was the most sensitive biomarker, strongly correlated with As body burden (R^2 = 0.84). Furthermore, bioavailability prediction of sediment As with the iron oxide impregnated filter paper (FeOF) extraction method had a strongly correlation with the As body burden in tested fish (R^2 = 0.86).

Keywords: Arsenic, sediment, bioavailability, toxicity, medaka fish

PP-52

Importance of Al/Fe oxyhydroxide coating and ionic strength in perfluorooctanoic acid (PFOA) transport in saturated porous media

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Understanding subsurface transport of per- and polyfluoroalkyl substances (PFASs) is of critical importance for the benign use and risk management of PFASs. As one of the most commonly found PFASs in natural environment, perfluorooctanoic acid (PFOA) was used as a representative PFAS and water-saturated column experiments were conducted to systematically investigate the effect of Al/Fe oxyhydroxide coating and ionic strength on its transport in this study. Our results showed a clear increase in PFOA retardation in Al/Fe oxyhydroxide coated sand (retardation factor: Al: 3.16-10.01, Fe: 1.35-3.25) than those in uncoated sand (1.09-1.20), due to the stronger electrostatic attraction between anionic PFOA and Al/Fe oxyhydroxide coated sand surface. Notably, Al oxyhydroxide have a more profound effect on PFOA retention and retardation than Fe oxyhydroxide. Besides, higher ionic strength significantly inhabited PFOA retention and retardation in positively charged sand, and the considerable retention of PFOA (~90%) in deionized water than those in 1.5 mM and 30.0 mM NaCl (<10 %) clearly proved the dominant role of competitive adsorption of Cl- on PFOA transport in positively charged sand. In contrast, higher ionic strength (0-30 mM NaCl) slightly increased PFOA retardation in negatively charged sand, illustrating that electrostatic interaction controlled PFOA transport in negatively charged sand. Our findings advance current knowledge to understand and predict PFOA transport in different surface charged natural media under environmental ionic strength conditions.

Keywords: perfluorooctanoic acid (PFOA), transport, Al/Fe oxyhydroxide coating, ionic strength

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Zinc pollution in zones dominated by algae and submerged macrophytes in Lake Taihu

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Zinc (Zn) contamination in lake zones dominated by algae and macrophytes in Lake Taihu was analyzed through diffusive gradient in thin films (DGT) and dialysis (HR-Peeper) methods. It was found that in both zones Zn contamination varied by season. In July and October, dissolved Zn was present in high concentrations, and in July, high concentrations of labile Zn were found in sediments. In July, reductive dissolutions of Fe/Mn oxides likely played a key role in the release of Zn, which was confirmed by both zones having the lowest percentage of the reducible fraction of Zn in July. Complexation of dissolved organic matter (DOM) with Zn may be responsible for the observed increase in the dissolved Zn concentration in October. This conclusion was supported by noting that October had the highest percentages of Zn-DOM complexes (25.3% and 34.4%) in the algae- and macrophytes-dominated zones, respectively. However, in January, low dissolved and labile Zn contents were observed in sediments in the two zones, suggesting that the decrease of Zn in sediments was caused by the adsorption of Fe/Mn oxides.

Keywords: Lake sediments, Algal blooms, Submerged macrophytes, Zinc pollution, High-resolution techniques

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Removal of Cu(II) ions from aqueous solution using petroleum coke-derived porous carbon: Investigation of adsorption equilibrium and kinetics

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Petroleum coke (PC)-derived porous carbons were developed through chemical activation using KOH and applied to adsorb Cu(II) ions from aqueous solutions. The effects of KOH/PC mass ratio and activation temperature on the preparation and physical properties of porous carbon were studied. Also, the effects of the initial solution pH, contact time, operating temperature, dosage of adsorbent, and initial Cu(II) concentration on adsorption were investigated in detail. A maximum Cu(II) ion adsorption capacity of 89.85 mg g^{-1} was attained at 30 °C using PCK3-450, the porous carbon sample prepared using a KOH/PC mass ratio of 3:1 at 450 °C. Adsorption isotherms were analyzed using the Langmuir, Freundlich, and Temkin models, and the experimental data fit well with the Freundlich model. Pseudo first-order, pseudo second order, Elovich, and intra-particle diffusion models were used to describe the adsorption kinetics, and the rate of adsorption conformed to the pseudo second-order kinetic model. The activation energy of Cu(II) ion adsorption on PCK3-450 was estimated at 29.61 kJ mol^{-1}, and thermodynamic parameters were discussed. The porous carbon adsorbents developed in this study are inexpensive and effective for Cu(II) ion removal from aqueous solutions.

Keywords: Heavy metal, Porous carbon, Petroleum coke, Equilibrium, Kinetics.

PP-55

Heavy Metals Content in Surficial Sediments in Coastal Vicinity off Malacca Straits

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The paper presents the distribution of heavy metal content in the surface layer sediments off the coast of Peninsular Malaysia of the Malacca Straits region. Teflon bomb digestion method applied and samples were detected by Inductively Coupled Plasma Mass Spectrometry (ICPMS). The distribution is then correlated with its mean size (Ø) and silt and clay percentages. There is a moderate linear relationship between Li ($r= 0.718$) and Zn ($r= 0.608$) and mean size. There were also moderate relationship when compared to silt & clay percentages for Li ($r= 0.819$) Zn ($r= 0.653$) Cu ($r= 0.653$). The area is dominated by fine sediments north of the area, around Pulau Langkawi other than at Pinang vicinities. Normalization with Li and enrichment factor (EF) are used in the assessment of heavy metal pollution in the area. Enrichment ranked Al> Fe> Mn> Ni> Co> Hg> Zn> Cr> Cd> Pb> Cu> As. The moderate enrichment input indicated anthropogenic input while the rest of metals in sediments were from natural sources. Multiple factors could influence the distribution include continuous anthropogenic input, water current of Selat Melaka, and sediment size.

Keywords: Malacca, Straits, heavy metal, sediment characteristic, enrichment factor, pollution

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Calculation and application of beryllium toxic factor in the assessment of potential ecological risk index

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As one of the prevailing approaches, the potential ecological risk index (RI) originated from Håkanson is a diagnostic method for water contamination control intent which considers metal ecological adverse influence, environmental adverse effect and toxicity. In this study, the toxic factor (=30) for beryllium (Be) is calculated dependent on Håkanson's fundamentals. Taking the case of Be polluted river, the environmental risk of Be in the surface sediments is evaluated by ecological risk factor (). This is then compared with the index of geoaccumulation (I_{geo}) and enrichment factor (EF). Results demonstrate that Be has the resemble contamination grades despite of , EF or I_{geo} indexes is applied demonstrating the appropriateness of the calculated toxic factor. Results of regression analysis further exhibit significant relationships between and I_{geo} and EF, revealing that that is a dependable and reasonable indicator for ecological assessment Be contamination in aquatic environment.

Keywords: Beryllium; Toxic factor; Potential ecological risk index; Sediments; Rongjiang River

PP-57

Chemical Speciation, Spatial Distribution and Risk Assessment of Trace Metals in the Sediments of Laguna De Bay, Philippines

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Laguna de Bay is a dynamic urban lake resource within an active volcanic field in the Philippines. The continuous uncontrolled economic development in its watershed has resulted to sedimentation and trace metal pollution in the lake. Trace metals can be deposited to the sediments and can still be remobilized into the water at certain physicochemical conditions. The goal of the study is to assess the sediment quality at the South Bay by characterizing the trace metal species through ultrasonic-assisted sequential extraction, principal component analysis, and ecological risk assessment. Increased total trace metal concentrations are found in sites nearest the coastal lake areas of Calamba and Los Baños. The trace metals at the South Bay were 17.48 ppm chromium, 15.51 ppm nickel, 123.94 ppm zinc, 109.49 ppm copper, 0.22 ppm cadmium, and 18.20 ppm lead, which have increased in over a decade, especially for copper and zinc. Cadmium has a high-risk level for potential ecological toxicity and primarily a by-product of human activities. Chromium and nickel are mostly bound within the minerals and primarily released through natural weathering, while the presence of copper, zinc, and lead are influenced by both lithogenic and anthropogenic processes. South Bay sediments have a moderate to considerable level for trace metal contamination.

Keywords: Bioavailability, Geographic information system (GIS), Principal component analysis (PCA), Sediment quality criteria, Sequential extraction

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Source apportionment of heavy metals in sediments and soils in an interconnected river-soil system based on a composite fingerprint screening approach

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Heavy metal pollution has been a global concern and key points of environmental pollution prevention and control due to the growing problems of urbanization and industrialization. To prevent and control heavy metal pollution effectively, it is necessary to accurately identify the sources of heavy metal pollution in the environment. However, rapidly and correctly apportioning sources of heavy metal is still a great challenge because of the stability of source fingerprint and complex interaction of multiple contaminants and sources. In this study, we perform a combination of optimization of pollution source fingerprint and source apportionment through jointly utilizing two machine classification and screening methods for characterizing the pollution sources of heavy metal in the sediments of an urban river and its surrounding soils. To attain the objective, pollution source samples and sediment/soil receptor samples were screened and collected from the typical urban industrial park, peri-urban river and its surrounding soils, respectively. Then, dominance-based rough set model (DRS), content optimization tools, and multivariate curve resolution-alternating least squares model (MCR-WALS) were employed to screen representative pollution source samples, optimize pollution source fingerprint, and apportion the potential sources of heavy metals, respectively. Further, Support vector machine (SVM), a machine-learning classification tool, was adopted to correspondence analysis results and pollution fingerprint based on the factor characteristics for achieving source apportionment accurately. Results showed that the pollution source pollution source fingerprints optimized by DRS and optimization tools are more representative and stable, and the results obtained by SVM and MCR-WALS are more accurate comparing with traditional methods. In particular, the optimized fingerprints of industrial pollution sources obtained obvious characteristic factors and stable crests. As whole, source apportionment suggested that printing and dyeing, chemical, electroplating, metal processing were the main origins of heavy metals in this area and the proportions of them in sediment and soil pollution sources were 67.05% and 46.27%, respectively. Results of the study can advance our knowledge to better understand the characterization of heavy metal pollution in the peri-urban ecosystem and to design effective targeted strategies for reducing heavy metal pollution diffusion.

PP-59

Source identification of Pb in different chemical fractions in sediments from Three Gorges Reservoir, China

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The Three Gorges Reservoir (TGR) region is one of several huge projects in China that are transforming the Chinese environment. The TGR sustains the health of the ecological environment in the middle and lower reaches of the Yangtze River, and the water supply security of the whole nation. Hence, the contamination status of the aquatic environment in the TGR has drawn particularly much attention in the science community. However, after impounding water into the TGR, little concern has arisen over Pb contamination in sediments from both mainstream and tributaries feeding the TGR. In this study, to explore the distribution and sources of Pb within the TGR, Pb concentrations and isotope ratios were measured in sediment cores collected from one mainstream and three tributaries. The results showed that sediments contained an average of 43.54 mg.kg^{-1} of Pb, roughly 1.6 times higher than the geochemical background concentration. Mainstream sediments showed higher average Pb concentrations but slightly less ^{206}Pb/^{207}Pb and more radiogenic ^{207}Pb/^{208}Pb ratios than all tributaries, indicating more severe Pb contamination in the mainstream. Most Pb occurred in reducible phases, with much less in exchangeable and oxidizable fractions; thus, Fe-Mn oxides may be the major sink of anthropogenic Pb. Bi-plots of ^{206}Pb/^{207}Pb versus Pb content and of ^{206}Pb/^{207}Pb versus ^{207}Pb/^{208}Pb indicated that coal combustion was the predominant anthropogenic Pb source for exchangeable, reducible and oxidizable fractions, while residual Pb mainly occurred naturally. The average percentage of coal consumption contribution was 60.3% for the Pb contamination in sediments in the lower reaches in TGR region. The results of our work highlight that controlling coal combustion would be efficient to reduce the introduction of new Pb into the TGR.

Keywords: lead contamination, Pb isotope ratios, sediments, sequential extraction, Three Gorges Reservoir

PP-60

The effect of lithium implementation on trace elements uptake by maize under hydroponic conditions

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In view of the lack of scientific literature about effects of lithium on the uptake of other elements by plants, studies were undertaken to determine the effect of lithium on trace elements uptake. The research was carried out under hydroponic conditions. Maize, ‘KB-270’ c.v, was chosen as test plant. The experimental design comprised 10 objects: the control and nine levels of lithium concentration in the nutrient solution (1.0-256.0 mg $\text{Li}\cdot\text{dm}^{-3}$ of the nutrient solution). The Hoagland nutrient solution containing Fe, Mn, Zn and Cu in the form of sulphate (VI) salts was used in all objects. In individual plant parts (leaves, inflorescences, stems, roots) the content of Mn, Fe, Ni, Cu, Zn, Cd and Pb was determined. Uptake of heavy metals and values of correlation coefficients between the content of Li and determined metals in individual parts of maize were calculated. The concentration of heavy metals was dependent on lithium concentration in the nutrient solution and on the index part of the plant. The above-ground parts and roots had significantly higher concentration of Mn, Ni, Cu and Pb at concentrations of 64.0, 128, and 256 mg $\text{Li}\cdot\text{dm}^{-3}$ in the nutrient solution in comparison to lower lithium doses (1.0-32.0 mg $\text{Li}\cdot\text{dm}^{-3}$). Addition of lithium to the nutrient solution, regardless of dose, caused a decrease in Fe, Zn and Cd content in maize roots in relation to the control. Statistical significance of correlation coefficients was calculated between lithium content in above-ground parts and nickel (0.6534), copper (0.3718) and lead (0.4511) content, and in roots, in addition to the statistically significant correlation between Li and Ni (0.3392) and Cu (0.6535), a positive correlation between Li and Fe (0.3909) were found.

Keywords: lithium, heavy metals, hydroponics, maize, translocation factor

PP-61

Boron Improves Productivity and Profitability of Bread Wheat under Zero and Plough tillage on Alkaline Calcareous Soil

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In Indo-Gangetic Plains, rice-wheat cropping system (RWC) is often practiced on alkaline soils low in organic matter and plant available boron (B). However, switching towards conservation tillage and B nutrition may help sustain the productivity of bread wheat in RWC. This study was conducted to evaluate the effect of B application on the productivity, profitability and grain B concentration of bread wheat sown under plough tillage and zero tillage systems. Boron was delivered through seed priming (0.01 M), foliage application (0.01 M) and soil application (1 kg ha-1). There existed significant interaction between B application methods and tillage systems for grain yield and quality traits in bread wheat. Seed priming was the most cost-effective method of B application in improving the grain yield of zero tillage wheat. However, soil applied B was the best in terms of yield improvement of plough tillage wheat. Soil and foliage applied B was better in improving the grain quality through increasing grain B and N concentrations irrespective of both tillage systems. Zero tillage in wheat increased the total soil organic matter by 8.2% than plough tillage wheat. Improvement in soil organic carbon (28%), soil microbial biomass nitrogen (45%) and soil microbial biomass carbon (27%) was also noted in zero tillage than plough tillage at 0-10 cm depth. In conclusion, B application, by either method, improved the performance and

profitability of wheat planted in plough tillage and zero tillage systems. However, seed priming and soil application were the most economical and cost-effective methods of B application in zero tillage and plough tillage wheat, respectively. Zero tillage system improved the soil health, physical properties and nutrients availability than plough tillage systems.

Keywords: economics, grain quality, rice-wheat cropping system, seed priming, soil health

PP-62

Zinc Nutrition in Chickpea for Improving Yield and Grain Biofortification

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Chickpea is an important grain legume, grown and consumed all over the world. It is mostly grown in rainfed areas and marginal soils with low plant available zinc (Zn). Soil Zn deficiency is often associated with human Zn deficiency due to low Zn concentration in the edible plant parts. To improve the chickpea yield and grain Zn concentration, a series of experiments as characterization of chickpea genotypes, optimization of Zn application rates and methods, in association with plant growth promoting bacteria (PGPB) under optimal and less than optimal conditions were conducted. Application of Zn through seed treatments, foliar and soil application alone and in combination with PGPB improved the chickpea yield, grain Zn concentration, bioavailable Zn and Zn use efficiencies. Moreover, chickpea types (*desi* and *kabuli*) differed in their response to Zn application methods and PGPB. In *kabuli* chickpea type, Zn application through seed coating + PGPB was more effective while in *desi* type, Zn application through soil application + PGPB was the most effective in improving the yield, bioavailable Zn and grain quality. The chickpea genotypes differed significantly for grain yield and bioavailable Zn under Zn application. Adequate supply of Zn during germination stages improved the drought and heat tolerance in chickpea. In conclusion, application of Zn alone and in combination with PGPB improved the yield, bioavailable Zn and grain quality of chickpea and may help cope with the malnutrition through Zn enriched supply of grain legumes.

Keywords: Zinc, chickpea, plant growth promoting bacteria, bioavailable Zn

PP-63

Screening of root system architecture of wheat (*Triticum aestivum*) cultivars efficient for iron scavenging

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Roots are considered hidden half of plant. Root architecture plays a significant role in nutrient mining and absorption. In current study a rhizobox experiment was conducted at University of Agriculture, Faisalabad in order to study the role of root system architecture in foraging iron at seedling stage. Experiment was completely randomized with four replicates. Seeds of one hundred and six varieties were obtained from NARC Islamabad, germinated in peteriplates and then transplanted in rhizobox. Wheat varieties were irrigated with nutrient solution with iron and without iron. Plants were harvested after 12 days. Root architectural attributes were studied after scanning roots by using smart root software. Various patterns of root system architecture were observed in control and treatment. Wheat varieties having higher grain iron concentration with broader and weaker root system architecture and lower iron grain concentration with broader and weaker root system architecture were screened out. Wheat varieties with higher grain Fe concentration as well as broader root system architecture showed more Fe foraging adaptability in Fe deficient environment as compared to control. This short-term study helped us to sort out varieties with adaptability potential in Fe deficient environment. This variability is due to the genotypic variation that stimulate the development of roots variously in Fe deficient rhizosphere.

Key Words: Rhizobox, soil iron, root adaptability potential, rhizosphere, Grain Fe content

PP-64

Improving the Productivity and Grain Biofortification of Spring Maize (*Zea mays* L.) through Zinc Nutrition under Drought Conditions in Changing Climate

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Malnutrition is affecting the health of people in the under developed countries. Shortage of water will also affect crop productivity in future. To address and overcome these issues, a pot experiment was designed to improve the productivity and grain bio-fortification of spring maize (*Zea mays* L.) through zinc nutrition under limited moisture supply. A completely randomized design (CRD) in factorial arrangement was used with four replicates. The treatments consist of two drought levels viz., well watered (70% water holding capacity), and drought stress (35% water holding capacity), two maize genotypes viz., DK-6525 (Monsanto) and High corn-8288 (ICI) with two levels of zinc treatments (0 and 10 mg kg^{-1} of soil). The results revealed that zinc application at 10 mg kg^{1} soil significantly ($p<0.05$) improved root fresh weight $plant^{-1}$, leaf length, leaf water potential, and grain zinc contents over control. Among the two genotypes DK-6525 perform better as compared to High corn 8288 under zinc application. In conclusion, application of Zn @ 10.0 mg kg^{-1} under well-watered and drought stress conditions improved growth, productivity and grain zinc contents.

Keywords: maize, genotype, growth, zinc levels, drought, seed yield

PP-65

Alleviation of Drought Stress in Maize Hybrid through Integrated Nutrient Management

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Drought stress is a principal global threat to crop productivity. Approximately, one third of the global cultivated area is prone to drought stress. Yield of maize (*Zea mays* L.) is often reduced by drought, and the severity of the problem may increase in future due to climate change. Therefore, developing different approaches to mitigate drought stress are inevitable to minimize the losses in maize yield. This 2-year field experiment was conducted to assess the effects of drought on maize growth, productivity and yield. The experiment was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad during spring of 2013 and 2014. Three soil moisture regimes were maintained in main plots as (I_1) well-watered, (I_2) mild drought with 25 mm of potential soil moisture deficit (PSMD), and (I_3) severe drought with 50 mm of PSMD. The nutrient levels were laid out in sub-plots and included: (T_1) control, (T_2) 100 kg ha^{-1} K, (T_3) 150 kg ha^{-1} K, (T_4) 12 kg ha^{-1} Zn, (T_5) 100 kg ha^{-1} K + 12 kg ha^{-1} Zn, and (T_6) 150 kg ha^{-1} K + 12 kg ha^{-1} Zn. The results indicated that crop stand, number of grain rows cob^{-1} and 1000- grain weight were improved under water deficit due to application on nutrients. The highest 1000-grain weight in 2013 and 2014 was obtained for I_1T_6 treatment. Similarly, the highest grains yield in 2013 and 2014 was obtained for the same treatment. Hence, optimized rates of potassium with zinc are needed to enhance maize production, increase net income, and alleviate the adverse effects of drought stress.

Keywords: potential soil moisture deficit, Zinc, drought stress, field capacity, growth

PP-66

Zinc bio-fortification in wheat through farmyard manure, acidified compost and ZnSO4 amendments

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Deficiency of zinc (Zn) is the main micronutrient problem for human health where food crops can play a crucial role in its supplementation. Therefore, a field experiment was arranged to assess Zn concentration and its availability through bio-organic amendments combined with Zn on wheat crop (Galaxy 2013) at MNS-University of Agriculture, Multan. Treatments included T0 = Control (no Zn, no Acidified compost, No FYM compost), T1 = Zn in soil (6 kg/acre as ZnSO4), T2 = Zn foliar (0.3% at three stages), T3 = FYM compost (300 kg/acre), T4 = Acidified compost (300 kg/acre), T5 = FYM compost (150 kg/acre) + Acidified compost (150 kg/acre), T6 = Zn in soil (6 kg/acre as ZnSO4) + FYM compost (300 kg/acre), T7 = Zn in soil (6 kg/acre as ZnSO4) + Acidified compost (300 kg/acre), T8 = Zn in soil (6 kg/acre as ZnSO4) + FYM compost (150 kg/acre) + Acidified compost (150 kg/acre), T9 = Zn foliar (0.3% at three stages) + FYM compost (300 kg/acre), T10 = Zn foliar (0.3% at three stages) + Acidified compost (300 kg/acre) and T11= Zn foliar (0.3% at three stages) + FYM compost (150 kg/acre) + Acidified compost (150 kg/acre). Zinc application has positive result on agronomic parameters of wheat plants including height, tillers numbers and weight of 1000 grain. Application methods of Zn, mainly foliar application + FYM and Acidified compost mostly affected the tillering capacity of plant. Grain yield and Zn concentration was maximum 507 g m2 and 51.44mg kg-1 by Zn foliar application combined with bio-organic amendments (FYM and Acidified compost) as compared to the control as well as increase in estimated bioavailability of Zn to 2.88 mg Zn per 300 g wheat flour. When maximum Zn concentration of grain and yield is desired, application of Zn by foliar + FYM and acidified compost was found resourceful method of Zn application.

Keywords: Acidified Compost, Compost, FYM, Wheat

PP-67

Breeding and Management Tactics for Developing Iron Biofortified Wheat Varieties

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Iron is essential for the human body. Despite the abundance of iron on earth, about two billion people worldwide are affected by iron (Fe) deficiency. Wheat is a staple food for majority of the world's population and thus could be a cheaper source of iron. Most of the iron in wheat grain, unfortunately, is not available for human consumption because of its binding with phytic acid. Iron biofortification of wheat, instead of supplementation, dietary diversification and food fortification, provides a pragmatic approach to solve the problem of iron deficiency. High yielding iron-rich wheat varieties can help to counter iron deficiency. For checking the possibility to breed such varieties, 144 diverse wheat genotypes were evaluated for grain iron and yield potential. Genotypes with high bioavailable iron contents were crossed in line × tester fashion with high yield potential genotypes. In the following year, both the parents and F_1 hybrids were tested for suitable fertilizer combination (nitrogen and iron). Gene action and heritability was checked for each trait and suitable hybrids were also identified. Iron contents ranged from 3.07-86.67µg/mg, phytate (PA) from 0.31-0.61mg/g, bioavailability from 0.34-15.77 and grain yield from 10.40-28.55g/plant in germplasm. Fe in hybrids ranged from 44.0-119.2µg/mg, PA from 0.4/2.9 mg/g, bioavailable iron from 0.6-4.6 and grain yield 5.5-42.2g/plant. The analysis (line × tester) indicated additive to non-additive with preponderance of non-additive type of gene action governing the expression of grain yield per plant, grain iron, grain phytate, bioavailability of iron, 1000-grain weight and other morpho-agronomic traits. Nitrogen application at rate of 150kg/ha to soil increased grain yield, 1000-grain weight, grain iron contents, grain phytate contents and iron contents in leaves signifying the importance of nitrogen fertilizer for improving grain iron and grain yields. There is an urgent need to start a robust breeding program for developing iron bio-fortified wheat varieties for the pursuit of healthy global life.

Keywords: iron biofortification, bioavailable iron, hybrids, wheat

PP-68

Exogenous Application of Potassium and Salicylic Acid modulates the dynamics of salt induced stress responses in different cultivars of rice

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Salinity stress adversely affected the growth, productivity and yield of rice from last few decades. Here, in this study the ameliorative role of exogenous spray of potassium (K) and salicylic acid (SA) have been investigated against salinity stress in rice. Four rice varieties (Kashmir Basmati, Basmati-370, Super-Basmati and Basmati-515) were exposed to NaCl stress (0, 100 mM) and sprayed with SA (0.02 %), K (0.1 %) and their combination (SA+K) at vegetative and flowering stages. Salinity stress caused reduction in morpho-physiological attributes (fresh/dry weight per plant, leaf area, chlorophyll contents (a, b and total), stomatal conductance and relative water contents. Moreover, the salt induced oxidative stress was confirmed by remarkable changes in plant metabolism (total soluble sugars, nitrate, nitrite reductase, proline), plant ionic relations (sodium, potassium, calcium, magnesium, phosphorus ions) and plant yield (number of tillers per plant, number of panicles per plant, harvest index and seed yield per plant). However, among four varieties, Basmati-370 exhibited best performance as compared to others and showed tolerance against salinity. The foliar spray of SA and K was effective in enhancing the morpho-physiological characteristics, plant metabolism and ionic relations in all varieties under saline conditions. It is concluded that salinity caused reduction in morpho-physiological attributes, ionic uptake and yield of four varieties of rice. However, Basmati-370 showed better stress tolerance regarding growth, ionic balance, biochemical attributes and yield. The application of potassium and salicylic acid is a good strategy for improving the performance of rice varieties under salt stress.

Keywords: salinity stress; potassium; stress tolerance; morpho-physiological traits

PP-69

Agronomic biofortification in wheat using glutathione and orgnanic biostimulant under saline condition

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Salinity affects the uptake of essential macro- and micronutrients to support plant growth, yield and grain nutritional quality. This study investigated the potential of glutathione (GSH), moringa leaf extract (MLE) and water (H_2O) applied in sequence as seed priming and foliar at seedling and tillering stages on plant nutritional status and grain biofortification (Zn, Fe, Mn) of wheat (*Triticum aestivum* L., cv. Sakha 93) under saline condition (9.10 d Sm^{-1}). Sequenced application of MLE, GSH and H_2O with MLE and/or GSH expressed highest grain yield at harvesting and accumulated maximum beneficial macro-(N, P, K, Ca) and micro-nutrients (Zn, Fe and Mn) by concomitantly reducing the deleterious Na^+, Cu, Pb and Cd concentration in wheat plants at booting stage under saline condition. The sequenced applied MLE, GSH and H_2O with MLE and/or GSH also showed increased grain nutritional concentration of Zn, Fe and Mn and reduced Cu in wheat under saline conditions. Sequenced applied GSH as antioxidant and/or MLE as plant based biostimulant improved grain yield, plant and grain nutritional status can be attributed to increased osmotic adjustment, ionic homoeostasis and activation of antioxidant defense system in wheat under saline conditions. Thus, integrative use of GSH and/or MLE can be best physiological strategy for agronomic biofortification in wheat under saline conditions.

Keywords: ionic homoeostasis, antioxidants, nutritional quality

PP-70

Split Application of Iron Improved Yield, Net Income and Grain-iron Concentrations of Mungbean (*Vigna radiata*)

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Nowadays malnutrition is the leading threat faced globally, and Pakistan is among the countries with higher rates of malnutrition. Pulses grown in Pakistan have small amount of micronutrients, especially iron (Fe) in grains compared to developed world. Biofortification, a process of integrating nutrients into food crops, provides a sustainable and economic way of increasing density of minerals/micronutrients in staple crops. Mungbean fulfills protein needs of large portion of Pakistani population; however, low Fe contents in grains do not provide sufficient Fe. Therefore, current study was conducted to infer the impact of different Fe levels and application methods on yield, economic returns and grain-Fe contents of mungbean. Mungbean was sown under four levels of Fe, i.e., 0, 5, 10 and 15 kg Fe ha^{-1} applied by three methods, i) as basal application (whole at sowing), ii) side dressing (whole at 1st irrigation) and iii) 50% as basal application + 50% side dressing (regarded as split application). Iron levels and application methods significantly influenced the allometry, yield, economic returns and grain-Fe contents of mungbean. Split application of 15 kg Fe ha^{-1} had the highest yield, economic returns and grain-Fe concentrations compared to rest of Fe levels and application methods. Moreover, split application of 15 kg Fe ha^{-1} proved a quick method to improve the grain-Fe concentrations which will ultimately solve the Fe malnutrition problem of the mungbean consuming population. In summary, split application of Fe at 15 kg ha^{-1} seemed a sustainable technique to enhance yield, economic returns and grain-Fe concentrations of mungbean.

Keywords: mungbean, agronomical biofortification, iron, yield, economic returns

PP-71

Seed Yield and Fatty Acid Composition in Sesame (*sesamum indicum* l.) as Affected by Silicon Application under a Semiarid Climate

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Sesame (*Sesamum indicum* L.) is a short duration, low input and highly drought tolerant conventional oilseed crop with high edible seed oil contents. This study was aimed to evaluate the response of various sesame genotypes to silicon (Si) application under a semi-arid climate. For this study, we hypothesized that Si application may improve seed yield, oil contents and fatty acid composition in sesame. The experiment was laid out in two factor-factorial randomized complete block design, replicated four times. The experimental treatments were four sesame genotypes (TS-3, G-120, SG-169 and SG-170) and three Si levels (0, 22 and 44 kg ha^{-1}). The data was analyzed statistically using the ‘Statistics 8.1’ software. The genotype TS-3 had the highest ($p \leq 0.05$) seed yield (479.1 kg ha^{-1}), oil content (40.2 %), oleic acid (41.8 %), and the lowest palmitic acid (6.37%) and linoleic acid (38.5 %). Si application significantly enhanced the seed yield, oil and unsaturated fatty acids (oleic and linoleic acid) contents and reduced the saturated fatty acid (palmitic and stearic acid) over control. The highest seed yield (487.8 kg ha^{-1}), oil contents (38.6%), oleic acid (40.9 %), linoleic acid (41.7 %), and the lowest palmitic acid (6.49 %) and stearic acid (3.66 %) were recorded with Si application at 44 kg ha^{-1}. The seed yield of sesame genotypes followed the order TS-3> SG-120>SG-169>SG-170.

Keywords: oilseed crops, crop nutrition, rainfed areas, oil contents, oil quality

PP-72

Improving the Quality and Yield Performance of Safflower (*Carthamus tinctorius* L.) through Foliar Application of Selenium

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Selenium (Se) an important role as a trace element in all the living organisms especially in humans; in plants, it can trigger a variety of plant growth cascades including germination and increase in the resistive ability of the crop plants against the abiotic stresses. This study was planned to investigate the foliar application of Se on quality and yield of different varieties of safflower. For this study we hypothesized that Se application at an optimum rate may improve the yield and quality of safflower. Selenium concentrations viz., 50, 100, 150, and 200 ppm were applied through foliar application on four safflower genotypes viz., 16427, 16493, 26733 and 26748. Se (200 ppm) significantly improved the plant height, number of branches, pods per plant, 1000-seed weight, seed and biological yield of safflower. Genotype '26748' performed better than the others. Se application at 200 ppm was effective for improving the yield and quality of safflower.

Keywords: crop nutrition, selenium, yield traits, oil content, safflower genotypes

PP-73

Boron Seed Coating along with Microbial Seed Inoculation Improved Productivity and Grain Boron Concentration of Chickpea

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Boron (B) is a crucial nutrient equally important for plants as well as human beings. The native soil fertility is very low in arid and semi-arid regions of Pakistan; and chickpea is grown as a leading pulse crop in these areas. Therefore, B deficiency is the leading constraint to limit chickpea productivity in these areas and inoculation with B solubilizing bacteria (BSB) can be helpful to improve B uptake. This pot experiment was designed to evaluate the effect of B seed coating along with BSB to improve growth, nodulation, and grain yield and grain-B concentrations of chickpea (*Cicer arietinum* L.). Chickpea seeds were inoculated with BSB i.e., Bacillus sp. strain MN-54 while un-inoculated seeds were taken as control. Inoculated and un-inoculated seeds were coated with B at the rate of 1.0, 1.5, 2.0, 2.5, and 3.0 g B kg^{-1} seed; however un-treated seeds were taken as control. Results revealed that B seed coating improved seedling growth, nodulation, grain yield and grains-B concentrations; however seed inoculation with BSB further enhance the performance. Seed coating with 1.5 g B kg^{-1} along with BSB inoculation was the best combination to improve seedling growth, nodulation and grain yield of chickpea. Moreover, higher grains-B concentration of chickpea was recorded at higher levels of B seed coating (3.0 g B kg^{-1} soil) along with BSB application. Boron seed coating improved grain yield 9-25% as compared to un-treated seeds. In conclusion, B seed coating at lower rates (1.5 g kg^{-1}) along with seed inoculation with BSB i.e., Bacillus sp. strain MN-54 seemed a viable option to improve nodulation, growth, grain yield and grains-B biofortification of chickpea.

Keywords: biofortification, malnutrition, boron solubilizing bacteria, nodulation

PP-74

Zinc Nutrition for Improving the Productivity and Grain Biofortification of Mungbean

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Mungbean [*Vigna radiata* (L.) Wilczek] is grown worldwide because of its high protein contents but its production is low due to zinc (Zn) deficiency. This study was conducted to assess the best mungbean genotype and Zn application method to enhance productivity and grain Zn biofortification. Two mungbean genotypes NM-92 and NM-2006 were grown using three Zn application methods and their combinations viz. osmopriming (0.01 M), soil application (10 kg ha-1), foliar application (0.5%), osmopriming + soil, osmopriming + foliar, foliar + soil and osmopriming + foliar + soil, whereas, hydropriming and no Zn application were used as control. The results indicated that stand establishment, allometric traits, grain yield, grain biofortification, net income and benefit cost ratio were more in genotype NM-92 at both sites (Layyah and Multan). In pot experiment, Zn osmopriming + foliar application enhanced grain yield (90.3%) and osmopriming + foliar + soil Zn increased grain Zn concentration (45.1%) in genotype NM-92. Among the sites, at Layyah, Zn soil application + foliar enhanced grain yield (63%) and the combination of osmopriming + foliar + soil increased grain Zn concentration (79%) in genotype NM-92. At Multan site, the grain yield and grain Zn concentration were enhanced by 63.7% and 31.6% respectively in genotype 'NM-92' with Zn soil application + foliar. Highest marginal net benefits were obtained with Zn foliar + soil application at both sites in mungbean genotype NM-92. The genotype NM-92 should be planted with Zn application as osmopriming + foliar + soil to attain better yield and grain Zn biofortification.

Keywords: Zinc, osmopriming, biofortification, grain zinc concentration, mungbean yield

PP-75

Poultry-mortality compost as an option to eliminate micronutrient malnutrition in humans

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Organic matter augment crop growth and yield by improving soil health and nutrient availability. Impact of organic amendment does vary mostly due to difference in nutrient availability. Poultry mortality (PM) compost was produced by decomposing dead poultry-birds with poultry litter in an aerated bin under natural microbial population. The compost was rich of macro as well as micronutrients. Three consecutive field experiments were conducted on wheat (*Triticum aestivum* L.) at different locations in Pakistan during 2016, 2017 and 2018 to investigate the effect of PM compost on the yield and quality of wheat. These experiments had two treatments of compost (PMC_1-1250 kg ha^{-1}; PMC_2-1850 kg ha^{-1}) with a control having no PM compost amendment. In control all recommended fertilizers were applied, whereas in PM compost amended treatments the amount of NPK present in the compost was subtracted from recommended fertilizers. All treatments were replicated three times. The results showed that 10-16% grain yield, 8-14% total biomass were increased at the highest compost level PMC_2. Poultry mortality compost also enhanced the phosphorus, potassium and zinc concentrations in shoot and grain of wheat with more pronounced effect in PMC_2. Furthermore, 8-13% increase in organic matter and 15-25% microbial biomass carbon was enhanced. In conclusion, application of PMC_2 compost ha^{-1} not only significantly enhanced the crop yield and grain-zinc concentration which is direly needed in developing world, especially due to widespread zinc deficiency. Improved soil health is further important for sustainable food production and food security in developing and poor countries.

Keywords: organic matter, biofortification, malnutrition, micronutrients

PP-76

Responses of micronutrients bioavailability to elevated ozone exposure in a flooded rice paddy system

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To investigate the effects of elevated tropospheric ozone (O_3) on the speciation and accumulation pattern of essential micronutrients (Fe, Mn, Cu, and Zn) from soil to rice (Oryza sativa L. cv. Nanjing 9108), the pot experiment rice was exposed to ambient and elevated O_3 in an open-top chambers (OTCs) system. The results showed that elevated O_3 decreased the roots, leaves and grains biomass of rice, and thousand grains weight by 22.31%, 54.04%, 24.17% and 9.42%, respectively. Elevated O_3 significantly reduced the Fe and Zn accumulation in rice plant, but increased the Mn and Cu accumulation, mainly by decreasing the available Fe and Zn together with increasing the available Mn and Cu in the soil. The concentration of Fe, Mn and Cu in rice grains showed no significant impact, but Zn significantly decreased by 56.37% under elevated O_3. This may affect the human body's intake of zinc nutrients through the consumption of rice. This study is critical to micronutrients management and adaptation strategies for sustainable growth of rice under future climate change.

Keywords: Elevated O_3, micronutrients, speciation, accumulation, *Oryza sativa* L

PP-77

Removal of Acid Orange 7 (AO7) dye from water by a magnetic red mud-derived biochar

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Red mud-derived biochar (RMBC) was prepared by the co-pyrolysis of waste tailing red mud and shaddock peel at different temperatures and mass ratio for its potential application of dye wastewater treatment and were characterized by SEM-EDS, XRD, FTIR, BET, XPS, and TOC. The results show that different types of iron-carbon composites have been produced, and RMBC produced at higher pyrolysis temperature (800℃, RMBC800) had the best performance on the removal of AO7 among all MRBCs. RMBC800 with feedstock mass ratio of 1:1 exhibited the best AO7 removal capacity (Langmuir Qmax=31.59 mg/g). The pseudo second-order kinetic model and Langmuir isotherm model precisely describe the adsorption process. Besides, RMBCs can be easily separated by magnetic field, which facilitate its application in wastewater treatment. This study provides a novel method for preparing magnetic red mud-derived biochar with significant AO7 removal capacity.

Keywords: Red mud biochar; Acid orange 7; Sorption; Degradation; Iron-carbon composite

PP-78

The performance of transition metal doped biochar as SCR catalyst

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The use of transition metal doped biochar catalyst, derived from different kinds of waste biomass, has been examined as potential catalyst for selective catalytic reduction of NO with NH_3 in the temperature range of 50-250 ℃. The influence of preparation methods, activation methods and surface modification, were investigated. The impacts of water (H_2O) and sulfur dioxide (SO_2) on the SCR activity of the biochar-based catalyst were also discussed. Analytical techniques, including BET, EA, in-situ FTIR, XPS, H_2-TPR, XRD, and SEM, were also employed to study the structural properties, elemental content, distribution of functional groups, morphology of the catalyst prepared. Experimental results suggested that the Ce doped sample exhibited higher NO_x conversion, better N_2 selectivity and broader operation temperature window than other transition metal doped biochar catalyst. Moreover, the Ce doped biochar catalyst has good sulfur tolerance, making the biochar-based catalyst as a promising NH_3-SCR catalyst for NO_x emission.

Keywords: Biochar, SCR Catalyst, NO_x, transition metal

PP-79

Removal of As (V) and phenanthren from wastewater by zirconium nanopartilces hybrid magnetic kitchen waste biochar composite

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Due to the huge production in daily life, kitchen waste disposal has become a thorny problem in China and even in the world. Similar to other biomasses such as agricultural straw, plant residues and feces, kitchen waste is also rich in organic carbon content, so it can be used as an ideal raw material for the preparation of biochar. As a highly effective adsorbent, biochar is widely used in the treatment of polluted soil and water. However, as the pristine biochar always does not have a high pollutant adsorption capacity, more functional modifications need to be added to raw biochar to improve its affinity to pollutants; Furthermore, due to its fine particles, it is difficult to recycle from the environment and its secondary effect on the environment is not clear after use. These shortcomings will limit the environmental application and technological development of biochar materials. Therefore, in this study, the pristine magnetic biochar was prepared from the kitchen waste (mainly bread and noodle waste) in the student cafeteria by means of the combination of iron solution impregnation and slow pyrolysis. And the porosity and aromatic structure were further improved by chemical activation. Subsequently, the zirconium hydroxide nanoparticles hybrid magnetic kitchen waste biochar composite was prepared by hydrothermal synthesis.At the same time, pristine biochar without magnetism and zirconia nanoparticles was prepared for comparison. It was found that with the increase of Fe content to 15 mM/g, the magnetism of magnetic biochar increased to 20 emu/g, while the specific surface area increased from 46.73 m^2/g to 110.57 m^2/g (Fe content increased to 15 mM/g) and then decreased to 73.25 m^2/g. These results indicated that magnetic biochar materials were successfully prepared by the combination of iron salt impregnation and slow pyrolysis method. Further activation of magnetic biochar material can increase its specific surface area by 3-9 times and improve its magnetic separation performance. Then the biochar samples were analyzed by X-ray diffraction (XRD), scanning electron microscopy (SEM) and high resolution transmission electron microscopy (HRTEM). Magnetic nanoparticles Fe_3O_4 were found immobilized in carbon matrix and zirconium hydroxide nanoparticles are evenly dispersed in the pores and surfaces of biochar. It is proved the zirconium hydroxide nanoparticles hybrid magnetic particle is a kind of core - shell multilayer structured composite. Finally, the potenial utilization of this kind of core-shell structured composite was evlauted with a serial of batch adsorption experiments. The results show that zirconium hydroxide nanopartilces hybrid magnetic kitchen waste biochar composite has better adsorption performance and higher magnetic separation recovery ability. In addition, the modified material can effectively remove As(V) and phenantheren from contaminated drinking water, irrigation water and river. This study shows that, with the kitchen waste as raw materials, zirconium hydroxide nanopartilces hybrid magnetic kitchen waste biochar composite can be successfully prepared by combining iron salt impregnation, slow pyrolysis, chemical activation and hydrothermal synthesis. The modified material is a potential new adsorbent with good ability of As(V) and phenantheren adsorption and magnetic separation and recovery.

Keywords: As (V), phenanthren, biochar, zirconium hydroxide, adsorption

PP-80

Characterization of soil pore structure of paddy soils under long-term rice straw biochar incorporation

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Soil pores play a key role in transportation of air, water, and heat, have effect on soil nutrient cycling and crop growth indirectly. Biochar is considered to be a potential soil amendment. however, the long-term field studies are lacking to conclusively ascertain the extent of biochar effects on soil pore structure. To evaluate the effects of biochar amendment on soil pore structure, undisturbed soil cores were collected in a long-term fertilization experiment, established in 2015, which considers the soil without biochar (C0NPK), and soil amended with 1.5 and 3.0 t ha-1 of biochar (C1NPK and C2NPK, respectively) treatments. Porosity, pore size distribution, connectivity, anisotropy, fractal dimension, porosity and mean macropore diameter of the limiting layer were measured by X-ray computed tomography (CT) and image processing. Biochar amendment increased soil organic carbon content and total porosity significantly by 18.7% and 10.5%, and decreased soil density by 7.4%. With the biochar application rates increased, there was no significant difference in the total porosity of the soil under the biochar amendment. however, the proportion of macropores had clearly changed. C1NPK increased porosity of 100-500 μm and >500 μm macropores by 81.6% and 275.3%, respectively, more than that of C0NPK. By contrast, the porosity of 100-500 μm and >500 μm macropores of C2NPK were decreased by 32.9% and 17.2% relative to C0NPK, respectively. C2NPK had higher porosity of <25 μm micropores than C0NPK and C1NPK. Meanwhile, connectivity, fractal dimension, porosity and mean macropore diameter of the limiting layer were highest under C1NPK, but anisotropy did not highlight significant differences among all the treatments. The results indicated that the application of biochar could increase the soil organic carbon content, total porosity and decrease the soil density of the paddy soil significantly. Proper application rate of biochar can increase the soil macroporosity and connectivity, but the soil macroporosity, soil hydraulic conductivity and gas diffusivity would be reduced under excessive application rate. These results enhanced our understanding of the relationship between soil pore structure following biochar application, and provided evidence for decision making process in choosing proper straw managements.

Keywords: biochar, soil pore structure, micro-CT

PP-81

Earthworms activities weaken the immobilizing effect of biochar as amendment for metal polluted soils

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The effect of earthworms on the immobilization of heavy metals by biochar was investigated using 4-week soil pot experiments. Our results showed that both sludge and rice husk biochars applied to Cd, Pb, and Zn contaminated soils significantly reduced the bioavailability of those heavy metals in soils, and their concentrations in soil pore water. The Cd and Pb concentrations in pakchoi shoots were decreased by 10.8% -11.7% and 21.5%-26.5%, respectively, in biochar treatments alone. Biochar and earthworm treatments, alone or in combination, can significantly increase pakchoi growth. However, compared with biochar-treated alone, applying earthworms into pots with biochar treatments significantly reduced soil pH by 0.1–0.19 units, increased the Cd, Pb and Zn concentrations in soil pore water, their bioavailability and total uptake in shoots. Additionally, earthworms weaken the immobilization effect of biochar on heavy metals. The results of principal component analysis and correlation analysis showed that earthworm treatment was the main cause of soil pH reduction, and soil pH was significantly negatively correlated with the bioavailable Cd, Pb and Zn concentrations in the soil. Furthermore, the effect of the earthworm digestive system (casts) on bioavailable Cd, Pb and Zn concentrations could not explain their changes in the soil. In addition, the application of biochar had no significant effect on the survival and heavy metal enrichment of earthworm. Therefore, the effect of earthworms must be considered in the process of Cd, Pb and Zn contaminated farmland soil remediation using biochar.

Keyword: Bioavailability; Biochar; Contaminated farmland; Earthworm; Weaken

PP-82

Evaluating biochar and its modifications for the removal of ammonium, nitrate, and phosphate from aqueous environments

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Removal of nitrogen (N) and phosphorus (P) from water and wastewater through the use of various sorbents is often considered an economically viable way for supplementing conventional methods. Biochar has been widely studied for its potential adsorption capabilities for soluble N and P, but the performance of different types of biochars can vary widely. In this review, we summarized the adsorption capacities of biochars in removing N (NH_4-N and NO_3-N) and P (PO_4-P) based on the reported data, and discussed the possible mechanisms and influencing factors. In general, the NH_4-N adsorption capacity of unmodified biochars is relatively low, at levels of less than 20 mg/g. This adsorption is mainly via ion exchange and/or interactions with oxygen-containing functional groups on biochar surfaces. The affinity is even lower for NO_3-N, because of electrostatic repulsion by negatively charged biochar surfaces. Precipitation of PO_4-P by metals/metal oxides in biochar is the primary mechanism for PO_4-P removal. Biochars modified by metals have significantly higher capacity to remove NH_4-N, NO_3-N, and PO_4-P than unmodified biochar, due to the change in surface charge and the increase in metal oxides on the biochar surface. Ambient conditions in the aqueous phase, including temperature, pH, and co-existing ions, can significantly alter the adsorption of N and P by biochars, indicating the importance of optimal processing parameters for N and P removal. However, the release of endogenous N and P from biochar to water can impede its performance, and the presence of competing ions in water and wastewater poses practical challenges for the use of biochar for nutrient removal. In conclusion, more progress is needed to improve the performance of biochars and overcome challenges before the widespread field application of biochar for N and P removal is realized.

Keywords: Biochar; Nutrient removal; Adsorption; Biochar modification; Water remediation

PP-83

Short- and Long-Term Biochar Cadmium and Lead Immobilization Mechanisms

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This research explored the mechanisms of soil Cd and Pb alterations and distribution following biochar (BC; 0 to 40 t ha^{-1}) amendment to a contaminated rice paddy soil, and the subsequent plant Cd and Pb tissue distribution over time. Water-soluble Cd and Pb concentrations decreased by 6.7-76.0% (short-term) and 10.3-88.1% (long-term) with biochar application compared to control. The soil exchangeable Cd fraction (i.e., considered more available) decreased, and the organic and residual Cd fractions (i.e., considered less available) increased in the short- and long-term with biochar amendment, likely a function of increased biochar functional groups present. Biochar application reduced Cd (16.1% - 84.1%) and Pb (4.1%-40.0%) transfer from root to rice grain, with rice Cd and Pb concentrations nearly reaching Chinese national food safety levels. Concomitantly, soil organic matter (SOM), pH and soil water content increased by 3.9%-49.3%, 0.05-0.35, and 3.8%-77.4%, respectively, with increasing biochar application rate. Following biochar applications, soil microbial diversity (Shannon index) also increased (0.8-46.2%) and soil enzymatic activities were enhanced. Biochar appears to play a pivotal role in sorbing or sequestering Cd and Pb in contaminated paddy soils, reducing heavy metal transfer to rice grain, and reducing heavy metal upward transfer to humans.

Keywords: Biochar; Cadmium; Lead; Contaminated; Paddy soil; long term

PP-84

Application of Biochar from Wood and Livestock Waste Mixture for Energy Supply and Odor Control

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Among the major organic wastes, livestock waste has been ranked top in terms of the production in Korea. With the spread of circular economy practices, the demand for the proper treatment and management of livestock waste becomes escalating. Despite the enormous potential of the livestock waste as a resource, only a tiny portion has been utilized as a renewable energy source. Conventionally, composting has been a common way to treat the livestock waste as a resource, however, zero energy farm system using livestock waste can be more attractive goal. The conversion of livestock waste to energy source has been achieved via biogas production, however, the biogas handling and the process management requires professional care. Therefore, the biochar production from livestock waste can be alternative for the energy recovery as well as the proper livestock waste treatment. Also, the biochar can be utilized for the odor control as the adsorbent for livestock systems. The goal of this research is the system development for the biochar production from livestock waste and the subsequent application for the energy supply and odor control. To ensure the heating value as an energy source, the wood waste was mixed with the livestock waste. The sawdust as the discharge from artworks at Hongik University was used as the wood waste, and the livestock waste was supplied from the livestock farmland located nearby Hongik University. The tube-type electric furnace was adopted to accomplish the carbonization process. Nitrogen gas was supplied throughout the heating and cooling period to keep no oxygen condition. The mixture ratio of wood and livestock waste was varied and heated less than 300C with the heating time 40 min or less. Before the carbonization process, the livestock waste was dried at 110C for 2 hrs to control its water content around 10% which is close to that of the wood waste. Without drying the livestock waste, the severe odor production and water collection in the furnace was found. The mass reduction after the carbonization was around 30% for the mixture of the wood and livestock waste. Currently, the heating value and surface area as well as the odor removal capacity of the produced biochar is being investigated to evaluate the biochar quality as the energy source and the odor-adsorbent. The ultimate goal is to design and operate a livestock farmhouse with the zero net energy and zero odor system, including the biochar production system.

Keywords: biochar, livestock waste, energy supply, odor control

PP-85

Potential Risk of Metal Halide Perovskite Solar Cells in the Environment: A Critical Review

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In recent years, solar photovoltaic technology has advanced due to growing interest in renewable energy sources. Metal-halide perovskite solar cells are among the most promising developments in solar photovoltaic technology. Metal halide solar cells can be categorized primarily as Pb based metal halide perovskite, Sn based metal halide perovskite and double perovskite solar cells. At present, there is considerable interest in using solar cells in agricultural sector to fulfill electricity requirements. Perovskite solar cells are constructed relatively stable and with proper encapsulation to avoid releasing of toxic materials to the environment. However, these toxic materials could be exposed to the environment through destruction of solar cells by natural phenomena such as hurricanes, hails, snow, landslides, fires, or via solar cell waste disposal. This may lead to potential environmental risks including contamination of soil and groundwater and the uptake of heavy metals by plants, subsequently affecting ecosystem and human health. This review summarizes and critically evaluates the current global status of metal halide-based perovskite solar cell production, their impact on environmental sustainability, food security and health issues. Further, the review discusses waste generated from metal halide based solar cells and potential methods for reducing toxicity by focusing on recycling, reuse and proper disposal.

Keywords: Electronic Waste, Phytoavailability, Recycling, Sustainable Waste Management, Toxicity

PP-86

Effect of Biochar on Immobilization of Pb in perovskite solar cell contaminated soils

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Perovskite Solar Cells (PSC) using metal halide perovskites has become promising technology due to their low cost and high efficiency. However, toxic materials inside solar cells such as Pb can be exposed to the environment due to natural disasters, accidents or rain. Subsequently, this may create a potential risk to organisms through contamination of soil and groundwater. In this study, Objectivity was to evaluate the effect of biochar on heavy metal mobility in solar cell waste contaminated soil and to investigate the underlying mechanisms involved in heavy metal dynamics in biochar amended solar cell waste contaminated soil. Biochar was produced from rice husk at two different pyrolysis temperatures, 550 ℃ (RHB 550) and 700 ℃ (RHB 700). Soil (silty loam) collected from an agricultural field in Busan was treated with 300 mg/kg of Pb^{2+} in the form of solar cell powder and perovskite solution. Soil incubation was taken for one month at room temperature and then treated with RHB 550 and RHB 700. All treatments were replicated four times and soil incubation was taken for one month at room temperature. Soil samples will be collected before and after addition of biochar and analyzed for pH, electrical conductivity, exchangeable bases, microbial properties, exchangeable cations, Pb^{2+} content and cation exchange capacity.

Keywords: Black carbon, Pb dynamics, Waste valorization

PP-87

Stabilization of multi metals-contaminated soil using rice straw biochar and phosphate

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Stabilization is a common remediation technology to reduce solubility and mobility of metals in soil, and the technique is considered as a cost-effective way to treat metals-contaminated soil.1) To achieve the stabilization of metals in soil, stabilizing agents are required including cement, fly ash, calcium oxide, and biochar. Biochar has various physicochemical properties including active functional groups and specific surfaces, which contribute to the stabilization of heavy metals through surface adsorption and complexation with functional groups1). Although biochar can be to stabilize heavy metals effectively, the stabilization of multiple metals is ineffective due to competitive binding of metals onto biochar surface, and finally the stabilization of metals is lowered. Thus, additional alternative agents are required to achieve effective stabilization of multi-metals in soil. Phosphate compounds are known as an effective agent to immobilize metals (e.g. Pb, Zn, and Cd) through precipitation of metal phosphate. Among them, diammonium phosphate (DAP, $(NH_4)_2HPO_4$)), a kind of phosphate fertilizer, can reduce the mobility of metal through the formation of metal–phosphate minerals2). Therefore, this study evaluated the stabilizing effects of biochar and diammonium phosphate on Pb, Zn, and Cu in soil. For this purpose, rice straw-derived biochar pyrolyzed at 600℃ and diammonium phosphate were applied to Pb, Zn, and Cu multi-contaminated soil. Then, we evaluated the efficiency of stabilization based on the TCLP(leaching test), phytoavailability, bioaccessibility, and BCR(sequential extraction procedure).

Keywords: Stabilization; Biochar; Diammonium phosphate

Acknowledge

This research was supported by National Research Foundation of Korea(NRF) funded by the Ministry of Education (grant number: 2018R1A2B6004284), and Korea Ministry of Environment(MOE) as Knowledge-based environmental service (Waste to energy) Human resource development Project (grant number: YL-WE-18-002).

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Heavy Metal Immobilization and Nutrient Release by Standard Biochars

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The Pb immobilization efficiency and release of soil nutrients were evaluated in contaminated soil amended with standard biochar. Biochar has been well known as a sustainable adsorbent for heavy metal immobilization or a competitive fertilizer in soils. This study adopted standard biochar which was produced from UKBRC (UK Biochar Research Centre). It is a set of biochar pyrolyzed under well controlled units and provided to biochar research groups worldwide, providing the standardized reference of biochar to researchers. Ten kinds of Standard biochar that derived from five kinds of feedstocks and each pyrolyzed at 550℃ and 700℃ were applied to the microcosm experiment. The microcosm was composed of 100 g of Pb contaminated soil with 2.5% (w w−1) biochar treatments in 70% of water holding capacity and incubated for 21 days. The available Pb was analysed to examine the immobilization efficiency. Most of the Standard biochar treatments performed Pb immobilization with different ranges. Especially, OSR 700 (oilseed rape straw at 700℃) and RH 700 (rice husk at 700℃) showed a significant decrease of available Pb content. The soil samples were analysed for pH, electric conductivity (EC), total nitrogen, organic matter contents, exchangeable cations. As a result, except SWP 700 (Softwood pellet at 700℃) biochar treated soils, soil pH increased from 6.0 to 7.0 and EC also increased from 0.0805 dS/m to 0.2707 dS/m. The largest increase of pH and EC was found with OSR 700 treatment. Correspondingly, OSR 700 treated soil showed the high content of exchangeable cations including the greatest concentration of K^+. The result of total nitrogen was varied among the standard biochars, while OSR 550 (oilseed rape straw at 550℃) treated soil showed a significant increase of nitrogen. This study suggests that OSR biochar is the most efficient biochar on Pb immobilization and fertilization.

Keywords: Lead contamination, Biochar amendment, Standard Biochar, Soil remediation

PP-89

Effects of gallium and indium on soil bacterial diversity

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Gallium (Ga) and indium (In) are metal elements belonging to the group IIIA in the periodic table, and present in trace amount in the Earth's crust. Due to their utilization in high-tech industries in Taiwan, occasional higher background of Ga or In in ground water near Hsinchu Science Park, where many semiconductor companies/factories are located, was reported, indicating their potential risk to our environment and human health. Soil microorganisms usually provide good resources to ameliorate impacts on the environment with metal contamination. However, the effects of those technology critical elements (TCEs) on microbial community in soil have yet to be determined although they are detrimental to animals and plants even at very low levels. When 100 mg L^{-1} of Ga, In or thallium (Tl) were amended in three different soils and incubated at room temperature for one day, we found that bacterial numbers were reduced dramatically in all thallium-treated soils whereas Ga has no negative effect on the bacterial number recovered on nutrient agar. On the other hand, bacterial number was decreased after treatment of In only in soils with lower pH value. Changes in microbial diversity were then evaluated using 16S rDNA sequencing with three soil types experimentally contaminated with different concentrations of Ga or In. The results showed that even no strong effect on bacterial number after treatment with gallium, the composition of bacterial species still changed a lot after one-month incubation, especially in the presence of higher concentration of Ga. Consistent with the culture-based method, even low amount of In has huge influence on bacterial diversity regardless of soil properties. In soil of Pc and Sk2 series, *Ktedonbacteriaceae* showed dose-dependent increase in abundance after incubation with gallium and indium. On the other hand, in paddy rice soil, most top ten families decreased their abundance after incubation with both heavy metals. In conclusion, gallium and indium have similar effects on changes of microbial composition in soil. Further investigation using culture-based approaches will help us understand how the bacterial population responds to those TCEs and the mechanisms underlying the TCE-resistant phenotypes.

Keywords: Technology-critical element; soil microbial dynamics; 16S rRNA-based metagenomic analysis

PP-90

Characterization of the technology-critical elements (TCEs)-resistance mechanism of *Luteibacter* sp. PCI1001 using a genome-wide approach

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Gallium (Ga), indium (In), and thallium (Tl), which all belong to Group 3A elements, are considered as technology-critical elements (TCE). As the key components for the second generation semiconductors, the utilization amount of such TCEs become larger and larger due to the emergence of photoelectric industry. Though these three heavy metals have not caused serious contamination problems yet, it is still a crucial issue of preventing their contamination of our environment as we have known that they are all very toxic to human, animals and plants. However, how they affect microbial composition in the environment has yet to be determined. In a previous study, we have known that the presence of these three elements can dramatically change the number and composition of the bacterial population in soil. In this study, we tried to characterize an In-resistant bacterium, PCI1001, which was originally isolated from Pinchen soil series in Taiwan. As PCI1001 can tolerate not only high concentration of In but also Ga and Tl, suggesting its role as a good model organism to study TCE resistance in bacteria. The whole genome sequence indicates that PCI1001 was 97% identical to *Luteibacter rhizovicinus* DSM16549, and the G+C content is 66%. The genome size of PCI1001 is 4.55 Mbp, smaller than *L. rhizovicinus* DSM16549 (~4.76 Mbp), and contains 3891 coding sequences. The minimal inhibition concentrations (MICs) of Ga, In and Tl of PCI1001 are 64 ppm, 64 ppm, and 3500 ppm, respectively. Using a random mutagenesis approach, we identified that the PAS domain S-box protein, UPFO149 family protein, RDD family protein, M1 family metallopeptidase, 5-methyltetra hydropteroyltriglutamate-homocysteine S-methyltransferase, sugar ABC transporter substrate-binding protein, and type 2 secretion system protein GspD may be involved in TCE resistance of PCI1001. Further analysis will help us understand how those genes participate in resistant mechanisms against TCEs in PCI1001, which has high potential to be developed into a biosensor or used in bioremediation or recycling of TCEs in the future.

Keywords: Technology critical elements; *Luteibacter rhiovicinus*; metal resistance mechanism; whole genome sequence

PP-91

Removal of hexavalent chromium by *Aspergillus niger* through reduction and accumulation

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The development of industrial activities leads to large quantities of wastes being discharged by electroplate factories and tanneries. These wastes often contain high concentrations of Cr(VI), which is harmful to living organisms. One effective tool to remove Cr(VI) is the use of microbes, since microbial remediation is more environmentally friendly than traditional chemical and physical methods. Among the microbes considered, it is notable that fungi as eukaryotes can secrete organic matter to enhance Cr removal through complex metabolisms. To better understand the Cr(VI) bioremediation capacity and mechanism by fungi, this study used *Aspergillus niger* as an example and analyzed its removal capacity. *A. niger* could resist and reduce Cr(VI) by nearly 100% at concentrations ranging from 10 to 50 mg/L. Overall, almost 97% of the Cr(VI) removal was caused by extracellular reduction whereas 3% by accumulation. The changes in the dry weight and Cr(VI) removal rate with time were also compared and exhibited a very similar trend over time, which indicated that Cr(VI) removal was highly dependent on the fungal growth and that metabolically active fungal cells played a significant role in Cr(VI) removal. To further confirm the Cr(VI) reduction capacity of different parts in fungal cells and find out whether the reduction process was enzymatic or nonenzymatic, the reduction capacity of both pristine and enzyme-inactivated cell fractions (cell secretions, CFE, and cell debris) was measured. CFE had the highest capacity to reduce Cr(VI) (by 100%), mediated by chromate reductase; followed by cell secretions (31.32%), mediated by nonenzymatic metabolites; and cell debris (25.80%), due to chromate reductase (22.1%) and physical adsorption (3.70%). SEM and EDX data showed extracellular accumulating chromium (Cr) formed precipitates on the hyphal surfaces. FTIR data demonstrated that functional groups like amino and phosphoryl involved in the Cr(VI) removal. TEM images and EDX data showed that some of the Cr was absorbed on the cell wall, and some of the Cr transferred to the cell. These data suggest that *A. niger*, which has the capacity to remove Cr(VI) by reduction and accumulation, will be a useful tool for Cr(VI) remediation.

Keywords: *Aspergillus niger*, chromium removal, reduction, accumulation, bioremediation

PP-92

Enhanced Cd remediation of magnetic biochar in soils and water by *Bacillus sp*. K1 and their influence on soil microbial community.

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Soil and water pollutions by Cadmium (Cd) are widespread environmental problems owing to their long-term adverse effects on ecosystems and humans. In this study, effective Cd(II) remediation in both water and soil was achieved by use of a composite synthesized by *Bacillus sp.* K1 loaded onto magnetic biochar and then encapsulated into sodium alginate gel beads. The maximum adsorption capacity of Cd(II) by the composite was 20.9 mg g^{-1}, which was approximately 2 times higher than that achieved by the raw biochars. Cell compartmentalization, SEM-EDS, XPS, FTIR and SR-XRF analysis showed that the predominant mechanisms of Cd(II) adsorption were probably by metal chelation by the cell wall of *Bacillus sp.* K1, ion exchange and complexation by surface oxygenic functional groups on biochar, which were enhanced by the addition of iron oxide. Soil incubation experiments indicated that *Bacillus sp.* K1 can successfully colonize soil when the composite is used. The composite treatment decreased soil available Cd from 260 µg kg^{-1} to 110 µg kg^{-1}, which converted HOAc-extractable Cd into residual Cd. In comparison with the application of magnetic biochar alone, which significantly decreased microbial diversity, the composite reduced the shift in the soil bacterial community. In summary, this low-cost and environmentally friendly composite is promising for Cd remediation in both aqueous solution and contaminated soils.

Keywords: *Bacillus sp*. K1; Magnetic biochar; Absorption; Soil remediation; Cadmium.

PP-93

Removal of Cd(II) and As(III) from aqueous solution by biochar-supported nanoscale zero-valent iron: Characterization and remediation mechanism

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The adsorption of Cd(II) and As(III) onto biochar-supported nanoscale zero-valent iron (nZVI-BC) was investigated in this study to understand the adsorption properties and remediation mechanisms. Scanning electron microscopy and Fourier transform infrared spectroscopy confirmed that nZVI particles were distributed on the biochar surface well. X-ray diffraction spectroscopy and X-ray photoelectron spectrometry revealed that metal ions were separated from solutions via electrostatic adsorption, complexation, oxidation, precipitation/co-precipitation, and the formation of type B ternary surface complex. The nZVI-BC (1:1) had a high removal efficiency in a wide pH range of 5.0–8.0 for Cd(II) and 3.0–8.0 for As(III), the experimental maximum Cd(II) and As(III) adsorption capacities were 33.81 and 148.5 mg/g within 2 and 1 h, respectively. In addition, synergistic effects considerably enhanced the adsorption capacity of nZVI-BC(1:1) in mixed adsorption systems, the adsorption capacities of Cd(II) and As(III) reached 179.9 and 158.5 mg/g, respectively. Hence, nZVI-BC(1:1) is a promising material for Cd(II) and As(III) removal from wastewater.

Keywords: Heavy metals, Nanoscale zero-valent iron, Biochar, Wastewater treatment.

PP-94

Assessment of bacterial communities and characterization of multi-metal resistant bacteria in the rhizosphere soils of phytostabilizer *Athyrium wardii* (Hook.) grown in a lead–zinc mine tailing

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Plant rhizospheric bacterial structure and function usually change a lot in adaptation to the long-term mining environment to tolerate high heavy metal concentrations, while there is no knowledge on the mining ecotypes (ME) of *A. wardii*, a Pb/Cd phytostabilizer original from a Pb-Zn mine. This study investigated the bacterial community of ME and non-mining ecotypes (NME) *A. wardii* by 16S rRNA gene amplicon sequencing. There was no significant difference in bacterial alpha-diversity between the ME and NME, and also between the rhizosphere and bulk soils. However, bacterial community structure differed between the soils. The ME rhizosphere harbored a unique bacterial community different from those in its bulk soil and NME counterparts. Several key taxa from *Protebacteria*, *Chloroflexi*, and *Nitrospirae* were more abundant in ME rhizospheres compared with the NME rhizospheres. In the ME rhizosphere, the abundance of *Sphingomonas* was 1.73- to 7.75-fold higher than that in other soil samples. The *Protebacteria* genus *Sphingomonas* was responsible for the majority of the divergence of bacterial community compositions between the ME rhizosphere and other soil samples. The bacterial community structure of the rhizosphere and bulk soils of *A. wardii* was closely related to ecological type and soil physicochemical property. Among them, pH and heavy metal concentration were the main driving factors for the changes of bacterial community. PICRUSt analysis predicted high relative abundances of imputed functional profiles in the ME rhizospheres related to membrane transport and xenobiotic metabolism. This study reveals the unique bacterial rhizobiome of the ME, which may play an important role in metal accumulation and improving the tolerance of *A. wardii* to heavy metals.

Keywords: Lead-zinc mining, *Athyrium wardii*, Bacterial community, *Sphingomonas*

PP-95

Mechanistic explanation for time-dependent hormetic effect of heavy metal on Scenedesmus obliquus

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Heavy metal may pose potential risks to ecological system and human health. Toxicities of heavy metal have been reported in many studies. However, a mechanistic explanation of the time-dependent hormetic effect of heavy metal is inherently limited. In this study, the time-dependent (1-8d) hormetic effects of four common heavy metals, Cd, Cr, Cu, and Hg, on *Scenedesmus obliquus* were investigated. The toxic mechanisms of hormetic effects were tested, including biomass, antioxidant enzyme activity, and cell membrane lipidation in algae cells. The results suggested that four heavy metals presented time-dependent stimulation in the low-dose range, where the stimulating effect increased with time. The biomasses in the cells of the *Scenedesmus obliquus* were gradually increased under the exposure of heavy metals. Both antioxidant enzyme activity and malonaldehyde (MDA) content were gradually reduced, and it also showed the typical time-dependent characteristics. As the concentration of heavy metals increased, the content of protein and chlorophyll increased at first and then decreased. The contents of catalase (CAT), superoxide dismutase (SOD), peroxidase (POD), and MDA decreased at first and then increased, which were consistent with time-dependent hormetic effect of four heavy metals. Thus, the time-dependent hormetic effect of heavy metal may be related to the mechanism of antioxidant stress in the cell, which may be caused by the bidirectional action of reactive oxygen radicals produced in the cell under the stress of heavy metals.

Keywords: heavy metal; hormesis; green algae; antioxidant stress

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Characterization of Metal - Microalgae Flocs based on ImageJ Image Software in Harvesting Process

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Algae can effectively remove metals from multi-metal solutions through adsorption, endocytosis and mastication. The application of microalgae as the adsorption material of heavy metals in wastewater has many advantages such as wide source of raw materials, easy cultivation, low cost, etc., and there is considerable potential for using them to treat heavy metal wastewater. Existing studies have shown that *Chlorella*, *Chlamydomonas*, *Spirulina*, *Microcystis* and other microalgae have a strong adsorption capacity for specific heavy metals, with a high removal rate of more than 90%. However, because microalgae is small and close to water in density, its harvesting difficulty and harvesting cost are important factors restricting its industrial application. Microalgae, with a certain negative charge, can be agglomerated by metal cationic flocculation and then settled from the solution. Concentration of metal and algae biomass in solution, pH, temperature, cations, anions and metabolic stage of the organism affect the formation of flocs. Characterization of the morphology of microalgal cell and flocs is a key to understand the microalgal harvesting process. In this study, ImageJ was used to characterize the morphological properties of microalgal cells as well as their flocs. The number based and weight based cell size distributions of *Scenedesmus acuminatus* in different growth phases were measured. Furthermore, the size distributions of flocs generated in the coagulation-flocculation were characterized to disclose the harvesting efficiency of coagulation based harvesting process. The results showed that the particle diameter of *S. acuminatus* has different distributions in different growth phases. After Al^{3+} coagulation in proper dosages, large sized flocs consisting of more than hundreds of cells of *S. acuminatus* were formed. The size of flocs has a positive correlation with the harvesting efficiency, but has a negative correlation with the solid content in the harvested biomass.

Keywords：Metal - Microalgae Flocs, ImageJ, Diameter distribution, Microalgae harvesting

PP-97

Use of *Yarrowia lipolytica* yeast to immobilize heavy metals in soil fertilized with waste

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In this study, an attempt was made to use *Yarrowia lipolytica* feed yeast to immobilize heavy metals in soil to which waste with different physicochemical properties was applied. The aim of study was to determine the effect of *Yarrowia lipolytica* yeast to reduce uptake of heavy metals by maize (*Zea mays* L.) growing on soil containing these metals. For this purpose a three-years pot experiment was carried out, in which the soil was fertilized with furnace ash and municipal sewage sludge in two doses, respectively: 60 and 150 g D.M. · kg^{-1}, 9 and 18 g D.M. · kg^{-1} of soil. The reference object was mineral fertilization in amount of: 0.3 g N, 0.08 g P, 0.2 g K · kg^{-1} D.M. of soil. Equally created objects to which *Yarrowia lipolytica* are used in amount of 90 · kg^{-1} D.M. of soil. In this study, assessment was based on yield of overground parts of maize, content and uptake of heavy metals by plant biomass. These studies showed that applying *Y. lipolytica* to soil with higher ash dose limited uptake of Pb, Cu, Ni and Cd by maize. The smallest uptake of tested heavy metals by maize was found in treatment where 150g of furnace ash was used. Based on the obtained results, it was found that *Yarrowia lipolytica* yeast may be recommended to limiting uptake and immobilization of heavy metals in soil.

Key words: feed yeast, immobilization, heavy metals, soil, uptake, waste

PP-98

Microplastics in Sediments: Occurrences, Accumulation of Organic Contaminants and Risks

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In recent years, microplastics (MPs) are widely recognized as a global environmental threat, and the environmental risks related to MPs have been paid more attention. Sediment is a major sink of microplastics and organic contaminants (OCs), where the interactions of MPs with OCs happen. Based on the current studies on marine sediments and freshwater sediments, the concentration of MPs in sediments is related to the population density, the proportion of urban area and industrial activities in the basin, among which the abundance of microplastics in sediments at the bottom is relatively large. MPs as a kind of synthetic organic polymer particles, have a strong adsorption capacity to the ubiquitous OCs in the environment, especially the hydrophobic organic contaminants (HCOs). The presence of less MPs can significantly affect the migration and bioavailability of OCs, while sediments may also accumulate OCs due to their large surface area, porous structure and bioaccumulation. Therefore, this review focuses on the accumulation of MPs in sediments leading to an additional increase in the absorption of OCs by sediments. For example, the distribution coefficient of phenanthrene between MPs-water is 2-3 orders of magnitude higher than the sediment-water distribution coefficient, and the phenanthrene carried by the microplastics will be released into the sediments under the influence of the concentration gradient. Under the influence of OCs in sediments, benthic animals and plants are amplified by the food chain, the long-term accumulation of toxic substances poses certain risks to the growth and even life and health of organisms.

Keywords: Microplastics; Sediments; Organic contaminants; Environmental risks

PP-99

The degradation performance of differet microplastics and thier effect on microbial community during composting process

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Microplastic, as a ubiqutious pollutant. has also been detected in organic waste such as sweage sludge, human and aminal manures. Comoposting is an effective mean to deal with the organic waste and produce compost. However, the variation of microplastic during composting has not been well studied..Hence, the objective of this study was to investigated the degradation characteristics of different microplastics (PE, PVC, PHA) after 60 days composting. The results indicated that the abundance and smaller size microplastics (0-800 μm) of all treatments were obviously decreased, except PVC microplastic. After composting, the surface morphology of microplastics occured obvious corrosion and fracture, the carbon content of PE, PVC and PHA were obviously reduced. All microplastics were signifcintly oxidized and the functional group O-H, C=O and C-O of microplastics were increased which were benefits for improving their biodegradability. Therefore, it was a conclusion that composting could be a useful method for disposing the microplastic in organic waste.

Keywords: Microplastics, Composting, Abundance, Surface morphology, Functional groups

PP-100

The Effects of the Configurations of Microbial Fuel Cell on Its Ammonium Removal Performance in Constructed Wetland

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It was reported that the ammonium removal performance could be improved by incorporating microbial fuel cell (MFC) into a constructed wetland (CW). In this study, several CWs with different MFC configuration were operated for 120d at an ambient temperature of 25℃~5℃ to investigate the effect of separator materials and the distances of the electrodes on the ammonium performance of the CWs. Under the conditions of influent ammonium concentration of 1.50mg/L and HRT of 2d (surface load of 78.50mg/(m^2.d)), the ammonium removal rates were kept between 69.20% to 79.44% in all CWs tested. it was shown that the average ammonium removal rate of closed-circuit CWs was 6.12% higher than that of open-circuit CWs. The addition of separator could increase ammonium removal efficiency by 7.51%, and the MFCs with a shorter distance between the cathode and anode achieved higher ammonium removal efficiency by 10.25%. It was also observed that the output voltage of the MFCs has a good relationship with the ammonium removal efficiency, which indicated that the performance of MFCs in favour of the ammonium removal process in CWs.

Keywords: microbial fuel cells, constructed wetland, ammonium removal; configuration optimization

PP-101

Contamination indices and ecological risk assessment of trace elements in soils from Malopolska province (Southern Poland)

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The aim of the study was assess the content and ecotoxicity of trace elements in soils from Malopolska province. The examined area is characterized by a high diversity of geological structure and types of land use and intensity of industrial development. The main sources of emission of pollutions are big industrial plants (especially mining-metallurgical activity), transportation, the power industry, and burning coal in individual home furnaces located in the Malopolska voivodeship. Further, the factors which influence heavy metal content in soils of in particular the west part of area are the Upper Silesian Industrial Basin and transfer of pollutants associated with this region. Soil samples used in study were collected from 320 different locations. The sampling points were systematically distributed in the study area, based on a 7.5 km × 7.5 km regular grid. Basic physicochemical properties (pH, grain size distribution, C-organic) and total trace elements content (Cd, Cr, Cu, Ni, Pb, Zn) were determined in soil samples. In order to comprehensively assess trace elements accumulation in soils, Geoaccumulation Index (I_{geo}), Single Pollution Index (PI), Enrichment Factor (EF), Potential Ecological Risk (RI), as well as 'Improved' Nemerow Index (INI) was calculated. Ecotoxicity of the soil samples was assessed using of three biotests consisting: Phytotoxkit, Ostracodtoxkit F and Microtox. Based on the research conducted, considerable diversity of total metal contents in the topsoil of the studied area was found. The highest values of coefficient of variation have been found for Zn – 351, Cd – 171% , and Pb – 148%. The observed mean levels of Cd, Pb and Zn were higher and Cr, Cu and Ni lower than the global average of those element contents in uncontaminated soils. Application of indices have given a conclusion that trace elements in soils represent in most cases low or moderate levels of contamination. Complex contamination indices showed that only 2.5% (RI) and 5.3% (INI) soil samples had a very high ecological risk to the environment, while calculated single contamination indices (I_{geo}, PI, EF) suggest that Cd, Zn and Pb are main cause of soil contamination. The highest content of those metals was found in the northwestern part of the area – the mining and metallurgical activity zones. On the basis of obtained results from biotests, 39% of soils were classified to class II as low toxic samples, 37% of the soils were in class III, meaning that these were toxic samples posing acute hazard. Class I (non-toxic) samples was determined for 11% of the studied soils. Class IV (highly toxic samples) and class V (very highly toxic samples) were represented by a total of 15% of soils.

Keywords: trace elements, geochemical indexes, biotests, ecotoxicity

Acknowledgements - The study was financed by grant no. N N305 107640 provided by the National Science Centre, Poland and from the subsidy for science granted by the Polish Ministry of Science and Higher Education, grant no. 010002-D014.

PP-102

The application of novel biochar-based composite amendments in reducing Cd availability in soils and Cd uptake by *Oryza sativa* L.

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The modification of soil amendments has been promoted to be a highly effective and economic strategy for enhancing Cd immobilization efficiency in soils. In this study, the effects of three rice straw biochar-based composite amendments modified by oxidation (RFW-A), high temperature (RFW-H), and naturally mixing with fly ash and white marble powder (RFW-P) on Cd availability in soils and Cd accumulation by rice were investigated by an incubation experiment, and a pot experiment together with a field experiment. The application of 2.5% RFW-H, 2.5% RFW-A, and 3.0% RFW-P showed better Cd immobilization efficiency, thus being an optimal choice involved in the following experiments. The application of 2.5% RFW-H, 2.5% RFW-A, and 3.0% RFW-P significantly increased soil pH, CEC and organic matters, inducing the transformation of Cd from HOAc extractable form into residual form, thereby resulting in decreased Cd availability in soils. Therefore, a significant decrease was observed for Cd accumulation in rice grains after the application of the three biochar-based composite amendments. RFW-A showed a greater decrease of 40.5% and 41.6% in the pot experiment and field experiment, respectively. Cd concentrations in rice grains after the application of RFW-A were less than the national food safety limit standard (0.2 mg kg^{-1}) in the pot experiment. Furthermore, the application of 2.5% RFW-A showed no significant effects on rice yield, and significantly increased the activities of catalase, dehydrogenase, urease, acid phosphatase, and alkaline phosphatase in soils. Thus, RFW-A shows great practical significance for the remediation and safe production of Cd-contaminated soils.

Keywords: Biochar-based composite amendments, Cd availability, Cd accumulation by rice, Food safety

PP-103

Effect of plastic mulch on metal contaminated soils

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Due to incomplete recovery, the plastic mulches are often remained in agroecosystem and fragmented into micro-sized particles. In addition, heavy metals are widespread in agricultural land by industrial and agricultural activities. The plastic mulch is likely to interact with heavy metals in the soils and how the co-occurrence of plastic mulch and heavy metal affects the soil properties and whether it induces an environmental risk are not proved. The objective of this research was to evaluate the changes in soil properties and heavy metal availability in response to the plastic particles originating from the plastic mulches. The soil sample, extremely contaminated by lead (Pb 1445mg kg^{-1}) and arsenic (As 1941mg kg^{-1}) was obtained from fallowed agricultural land near the Tancheon mine in Gongju-si, S. Korea. First, based on environmentally relevant concentrations, soil microcosms were designed in the presence of metals in agricultural soils and low density polyethylene (LDPE) based plastic mulches (<5mm) by different abundances (i.e., 0.1%, 1%, 3%, 5%, and 7%, w w^{-1}), and incubated at 25℃ and 70% water holding capacity for 7, 14, and 30 d. The plastic mulch effects on soils were estimated through measurement of soil physicochemical and biological properties. The addition of plastic mulch led to increases in soil acidity (i.e. pH) and electrical conductivity (EC). Although the soils incubated during 7 d showed higher acidity than 30 d, no remarkable tendency of plastic mulch on EC was found depending on incubation periods. Additionally, soil microbial communities were varied by plastic mulch effects. By regarding these results, the exposure to plastic mulch changed properties of metal contaminated soils and it could bring significant impacts on agroecosystem. This work was carried out with the support of “Cooperative Research Program for Agriculture Science and Technology Development (Effect of plastic mulch wastes on crop productivity and agro-environment, project no. PJ01475801)” Rural Development Administration, Republic of Korea.

Keywords: plastic mulches, heavy metals, soil properties, agroecosystem

PP-104

Impact of Wind on Copper Footprints in a Large River-connected Lake

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In this study, a particle-tracking model was used to simulate the Cu footprints in Poyang Lake under the dual action of complex wind field and lake flow pat-terns. When ignoring the wind field, the results showed that the gravity flow and top-lifted flow both drove Cu particles to move from south to north, and the backward flow slowed down the velocity of Cu particles, but did not affect the final trend. When considering the wind field, wind-driven currents had an effect on the horizontal lake flow patterns. Under the influence of wind-driven current, the top-lifted flow was the most vulnerable, the backward flow ranks the second and the gravity flow ranks the third. The results demonstrated the importance of the effect of wind on lake circulation and mixing. Better knowledge on heavy metal footprints in large river-connected lake was provided to guide the future water management.

Keywords: copper, lake flow pattern, particle-tracking model, river-connected lake, wind-driven current

PP-105

Phytoremediation Potential of Vetiver Grass (Chrysopogon Zizanioides L.)

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The aim of this research was to investigate the potential for the use of vetiver grass (Chrysopogon Zizanioides L.) to remediate metal-polluted sites. This study was performed in industrially polluted soils containing high concentrations of Zn, Pb and Cd, situated at different distances (0.3, 3.5 and 8.0 km) from the source of pollution - the Non-Ferrous Metal Works near Plovdiv, Bulgaria. On reaching commercial ripeness the vetiver grass were gathered and the contents of heavy metals in their different parts – roots, stems, and leaves were determined after microwave mineralization. Physico-chemical characterization, total, and DTPA extractable metals in rhizospheric soil samples were carried. Translocation factors (TFs) were also determined. The quantitative measurements were carried out with ICP. The essential oil of the ground vetiver roots was obtained by steam distillation in laboratory conditions The oil analysis were performed using by gas chromatography mass spectrometry (GC/MS), and about 15 compounds were identified in oil, mainly sesquiterpenes. The main compounds of essential oi were as follows: khusimol (29.40-30,25), valerianol (9.07-10,33), guaiol acetate (7,83-8,15), vetiselinenol (7,27-7,84), α-vetivone (6,79-7,12), junenol (5.87-6,36), (e)-isovalencenol (5,95-6,42), β-vetivone (5,21-5,62), 10-epi-γ-eudesmol (3,85-4,15), β-vetivenene (3,38-3,55), β-vetispirene (3,14-3,39), 7-epi-α-eudesmol (3,12-3,37), and α-Amorphene (2,30-2,44). The vetiver grass is a tolerant to heavy metals and can be grown on the highly heavy metal polluted soils. Bioaccumulation factor and translocation factor values (BAF and TF < 1) were less than one suggesting low accumulation in the shoots. The plants are characterized by a low capacity to absorb and accumulate Pb, Cd and Zn, and show no signs of toxicity (chlorosis and necrosis) in content of 36.8 mg/kg Cd, 1158.8 mg/kg Pb and 1526.2 mg/kg Zn in the soil. The vetiver grass may be preferred as a good candidate for phytostabilization and can be successfully used for phytostabilization of heavy metal polluted soils.

Keywords: vetiver grass, heavy metals, polluted soils, phytoremediation

Acknowledgements: The authors gratefully acknowledge the financial support by the Bulgarian National Science Fund (Project DFNI H04/9).

PP-106

Cu/Cu_2O-immobilized cellulosic filter for enhanced iodide removal from water

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Radioactive iodine(^{129}I, ^{131}I) produced by uranium fission was the most radioactive material exposed to nature at the time of nuclear accidents. Radioactive iodine causes thyroid cancer. It is important to develop a method for removing radioactive iodide ions (I^-) dissolved in the water system. Cu^+ and I^- have a high affinity toward each other according to the theory of hard and soft acids and bases (HSAB). Researchers have attempted to remove iodide ions in the form of nanocomposites by combining Cu_2O with zero-valence metals. However, these nanocomposites are small particulate matters, which makes it difficult to collect them after adsorption of the radioactive iodide. Therefore, we developed a Cu/Cu_2O-immobilized filter-type adsorbent for efficient iodide anion removal. A cellulose filter (CF) was used as a support, and its surface was modified using acrylic acid to enhance copper immobilization. The modified filter (CF-AA) exhibited 10x higher copper immobilization than the unmodified filter. Cu/Cu_2O was prepared on CF-AA by using a simple hydrothermal method to obtain CF-AA-Cu. While CF and Cu_2O themselves exhibited limited iodide adsorption performance, CF-AA-Cu exhibited a high adsorption capacity of 10.32 mg/g, as obtained using the Langmuir adsorption isotherm model. The adsorption mechanism was proved through material characterization before and after adsorption. Overall, iodide adsorbents in the form of filters with high adsorption capacity are potentially useful for the removal of iodide from water.

Keywords: Radioactive iodide, Adsorption, Cu/Cu_2O, Cellulose filter, Hydrothermal synthesis

Acknowledgment: This study was supported by the Creative Convergence Research Project (CAP-15-07-KICT) of the National Research Council of Science and Technology (NST).

PP-107

Enhanced ammonium removal at low temperature by multimedia constructed wetland and microbial fuel cell system

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The performances of ammonium removal in the multimedia constructed wetland (MCW) combined with microbial fuel cell system (MFC) under low temperatures were investigated. MCWs were made up of gravel, large ceramic grains, small ceramic grains and zeolites, and carbon felts were laid in some MCWs as the electrodes to combine MFC with MCW. The results showed that when the temperature dropped from 25℃ to 5℃, the ammonium removal rate of the CWs used in this study decreased from 97.70% to 87.19%. The adsorption capacity of zeolites for ammonium was tested to be 7.79 mg/g at 5℃ in this study, which contributed significant ammonium removal under low temperature. The ammonium removal rate before the zeolites layer in MCW decreased to 40.13%, and that of MCW combined with MFC decreased to 67.64 % at 5℃. It was also showed that the amount of microorganisms in MCW-MFC decreased by 13.76% when the temperature dropped to 5℃, which is lower than that of MCW as 33.27%, and the relative abundance of nitrifying bacteria was 11.63% higher in MCW-MFC than that of MCW, according to the results of high throughput sequencing, which could account for the enhanced the performance of nitrogen removal.

Keywords: Multimedia; Constructed wetland; Microbial fuel cell; Ammonium removal

PP-108

A pilot-scale test for recovery water from RO concentrates by pervaporation

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Pervaporation is a membrane separation technology driven by heat, which is widely used in desalination and dehydration of organic solutions. The feasibility of recover water from concentrates from reverse osmosis (RO) process was investigated in this study. The concentrates were taken from a RO unit treating leachates, with the COD of 2950 mg/L, EC of 28700 µs/cm, pH of 6.51. A hydrophilic pervaporation membrane was fixed on a flat-plate to make flat membrane module, a flux of 3.6 LMH was obtained with the temperature of the concentrates of 70℃, the vacuum pressure of the permeates side of -90KPa. The COD concentration, EC and pH value in the permeates were 10 mg/L, 20 µs/cm and 8 respectively, which could meet the requirements for reuse. The costs of water recovery could be much lower when there is a sufficient amount of waste heat.

Keywords: pervaporation, RO concentrates, waste heat, water recovery

PP-109

Extracting of phosphorus and metals in sulfuric acid from the sludge-derived hydrochar

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Hydrothermal carbonization is considered as a potential sustainable waste management technology, which has the characteristics of reduction, stabilization, harmlessness and resource utilization. The sludge is converted into phosphorus-enriched hydrochar during hydrothermal carbonization, which can realize the recycling of phosphorus to meet the potential shortage of phosphorus resources. In this study, chemical extraction experiment of phosphorus recovery from sludge-derived hydrochar was carried out in sulfuric acid, taking into account the co-solubilization influence of calcium, iron and aluminum. By exploring the effect of different sulfuric acid concentration, leaching time and solid-liquid ratio on phosphorus extraction, the leaching process conditions were optimized for phosphorus recycling. Sulfuric acid leaching experiments show that acid concentration has a greater effect on the leaching of phosphorus and metals. Longer leaching time will cause the formation of calcium sulfate in the solution, reducing the leaching efficiency. The solid-liquid ratio will affect the contact area, and it is also an important technical index. The study found that the form of phosphorus in hydrochar is mainly calcium phosphate and magnesium phosphate, which will facilitate the extraction of phosphorus. Therefore, under the condition of sulfuric acid concentration of 0.5mol/l, leaching time of 120min and solid-liquid ratio of 50ml/g, the leaching result of phosphorus is the best, with the leaching rate of 93.8%, and the leaching rates of calcium, iron and aluminum are 70.4%, 54.5%, and 65.8%, respectively. Therefore, in the process of phosphorus recovery, it is also necessary to consider the separation and recovery of metals.

Keywords: sulfuric acid, sludge-derived hydrochar, phosphorus recovery, metals, extracting

PP-110

Optimization of lixiviant composition for selective metal extraction

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Metal recycling from residues produced by mineral extraction and metal processing industries serves as an opportunity to bring metal resources back to the economy and promote sustainability. Presently, bioleaching is gaining attention as a greener technology for metal recycling from secondary solid wastes compared to the traditional hydrometallurgical processes. Although bioleaching of metals has been proven to be technically feasible, its practical application, however, still faces challenges related to the selectivity towards metals of interest. Thus, we propose the use of lixiviant mixtures, response surface methods, and desirability functions, combined with the use of an automated platform, as tools to optimize the lixiviant compositions for selective metal extraction. The leaching tests were performed on an Fe-rich residue obtained from Zn refining. The lixiviants used in this study were citric acid (CA), ammonium carbonate (AC), and gluconic acid (GA). Several combinations of the three-component lixiviant mixtures (CA–AC–GA) were formulated to investigate their Zn leaching capacity and selectivity over Fe extraction. The data from the batch leaching experiments performed using an automated platform were analyzed using response surface method. The most favorable combinations were selected using the desirability functions set at lower (10 mg/g Zn, 0 mg/g Fe) and upper (33 mg/g Zn, 33 mg/g Fe) limits of Zn and Fe leaching capacities after 3 days of incubation. In terms of Zn leaching, optimal combinations contain only CA and GA. However, CA and GA combinations possess a lower Zn over Fe selectivity. The combination of 33 % AC, and 67 % GA resulted in 29 mg/g Zn and 14 mg/g Fe leaching capacities, suggesting improvement of Zn selectivity over Fe. Moreover, it achieved an overall desirability of 0.68 (0 being the least desirable and 1 being the most desirable), which is the optimum among the combinations tested. Based on this optimum combination, a secondary screening was performed to further improve the overall desirability. The results of this study suggest that the presented approach can be an effective tool to improve the selectivity of lixiviant mixtures for the target metals. In order to substantiate such approach, further tests are necessary involving a wider range of secondary metal resources.

Keywords: bioleaching, metal selectivity, desirability function, automated platform

PP-111

Selective copper recovery from ammoniacal waste streams using a systematic biosorption process

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Liquid waste streams containing Cu and NH3 present an important secondary Cu resource that could bring economic benefits and sustainability. Conventional recovery methods for this type of waste are generally costly, environmentally damaging, and non-selective towards Cu. Thus, we propose the use of a systematic biosorption process as an efficient and selective approach to remove and recover Cu in the presence of NH3. Five biosorbents with different properties—pine cone (PC), brown macroalgae *Fucus spiralis* (FS), chitosan (CT), sewage sludge biochar (SSBC), and lignin-rich digested stillage (LRD)— were selected from a set of low-cost materials screened for the adsorption of Cu from NH3 solutions. The effects of different process parameters on the adsorption of Cu onto the five biosorbents were investigated. Biosorbent surface characterizations and chemical speciation modelling were also performed to understand the Cu adsorption trends better. The most favorable Cu removal was observed at pH 11 for all biosorbents, except PC, which worked efficiently in a wider pH range. The *qmax* (mmol/g) of the biosorbents for Cu in the presence of 2 M NH3 at pH 11 follow the order: CT (1.56) > PC (0.94) > FS (0.91) > LRD (0.87) > SSBC500 (0.30). All biosorbents showed selectivity for Cu over Zn. Furthermore, the presence of 5 mM Zn increased the *qmax* of PC and FS to about 1.10 mmol/g. When used in a real leachate containing 6 mM Cu(II), 1.1 mM Zn(II), 1 M NH3, and 0.5 M $CO3^{2-}$, PC still achieved a relatively high Cu removal efficiency of about 70 %. All gathered information were coupled with chemical speciation modelling and surface characterizations to determine the parameters and biosorbent properties contributing to a selective Cu biosorption process. The results of this study suggest that biosorbents screening, chemical speciation modelling, and biosorbent surface characterization can be used as effective tools in finding a biosorbent that could work for a particular waste stream. This approach should be further tested on other secondary metal resources for validation. For this purpose, a high-throughput automated platform will be used to perform the adsorption experiments for different waste streams in a shorter period of time.

Keywords: biosorption, Cu-NH3 complexes, metal recovery, selectivity, speciation

PP-112

Circular Economy Strategies for Unravelling Tantalum Supply Issues

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Tantalum is labelled as a critical element due to supply challenges. A high demand, finite reserves, limited substitutes and the political-economic instability of countries supplying primary sources all add to the challenge. The recovery through recycling to date is also weak. Tantalum has high economic importance owing to its use in almost every electronic product. Unsteady supply chain of tantalum can cause serious problems in information and communication sector of a country. The implementation of the principles of circular economy can be a solution to reduce supply risk of tantalum. Circular economy for tantalum has not been established. In practice, the material flow of tantalum in the economy cannot be completely close, but efficient extraction, use and recycling are the basic strategies to keep the metal in the value chain. This work highlights the challenges, opportunities and solutions in closing the material cycle of tantalum. A systematic approach has been developed to identify the losses at different stages of material life cycle of tantalum and practical economical strategies are recommended to curtail these losses. The finding of this study shows that the supply chain of tantalum as well as economical, ecological and technical recycling issues are the bottlenecks for developing the circular economy of tantalum. Limited coordination and policy integration between different stakeholders, including national authorities, non-profit companies and producers is another serious problem that has to be addressed. The benefits of a circular economy concept for different stakeholders and its significance for economic growth, and the environment is also highlighted in this study. Although the circular material economy is difficult to achieve it is the only solution to increase the longevity of natural resources and reduce the environmental burden by minimising the waste production.

Keywords: Circular economy, Tantalum, Critical metal, Environmental burden

PP-113

The Formation Process of Melting Slag for the Recycling of Automobile Shredder Residues

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The gasification of Automobile Shredder Residue (ASR) was performed using fixed-bed reactor for the recovery as energy resources. The capacity of fixed-bed reactor was 1kg/hr and the experimental temperature was 800, 1,000, and 1,200 ℃. The equivalence ratio(ER) was ranged from 0.1 to 0.5. The syngas yield composed of hydrogen and carbon monoxide was ranged from 40% to 86%. The syngas yield from the process increased as the gasification temperature increased. In addition, the melting experiment of char and ash from the gasification process was performed for the recycle as the clay bricks from the melting slag. The pore number of melting slag increased as the gasification temperature increased. The strength of melting slag was higher than that of the standard clay bricks. As the results, the melting slag content and the gasification temperature were optimized as 10 wt % and 1,300℃, respectively.

Acknowledgement

This work was supported by the National Institute of Environmental Research (NIER). This work was also supported by Korea Institute of Energy Technology Evaluation and Planning (KETEP) and the Ministry of Trade, Industry & Energy (MOTIE) of the Republic of Korea (No. 20184030202240).

Keywords: Automobile Shredder Residue; Recycling; Gasification; Melting; Slag

PP-114

Study on the bioavailability of heavy metals in soil-crop system reduced by biochar: a field experiment

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Soil contaminated with HMs has been a global trouble, which obstructs the production of agricultural and does serious harm to human health. Anthropogenic activities like smelting, sewage irrigation, and the abuse of pesticides and fertilizers, are the main causes of soil pollution. It is of great significance to control the spread of pollution at source and the risk of HMs in soil-crop system around mining or smelter areas needs more attention. Biochar is a remediation material for HMs polluted soils. However, studies about the application of biochar in field experiment under the rotation condition of crops are absented. The main objectives were: 1) to explore the effects of biochar on the physical and chemical properties of R soils with the performance of different crops; 2) to compare the influence of biochar on crop growth; 3) to research the changes of total and geochemical fractions of HMs and in R soils; 4) to investigate the accumulation of HMs by different crops.

Keywords: Lead-zinc mining, *Athyrium wardii*, Bacterial community, *Sphingomonas*

PP-115

Effects of addition of treated sewage sludges on soil heavy metals fractions and microbial characteristics in an abandoned mining area

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In this study, a pot experiment was carried out to study the effects adding sludge treated by three methods on the fractions of heavy metals and the characteristics of microorganisms of abandoned mining areas soil. The results of this study show that After adding dewatered sludge, aerobic fermentation and anaerobic digestion sludge, the pH of soil decreased and the conductivities increased to 908, 552 and 1144 $\mu S\cdot cm^{-1}$ respectively, which had lowest amplification in soil adding aerobic fermentation sludge. The organic matter contents increased to 25.6 $g\cdot kg^{-1}$、 32.1 $g\cdot kg^{-1}$、 33.3 $g\cdot kg^{-1}$ respectively. After adding three kinds of treated sludge, except for As and Pb, the contents of other elements increased obviously. Compareing with the background values of soil in the Yangtze-Huaihe River Basin of Anhui Province, the contents of Cr, Cd and Pb in the control group were lower than the background values, while the contents of other elements and heavy metals in the soils adding sludge were higher. The residue fraction of Cr, Ni, Cu, Zn and As reduced in varying degrees, the F1 fraction proportion of Cd element increased to 30.66%~42.03%, and Pb elements mainly transformed between F2 and F3 fractions; The effects of adding aerobic fermentation sludge on the content and availability of heavy metals in soil was the smallest, except for the Cd element. During the whole experiment, the contents of heavy metals decreased in varying degrees, the fractions of heavy metals changed with time. The microbial biomass C, N and key enzymes activities of abandoned mining area soil adding sludges improved in different degrees. Adding different sludges can promote microbial reproduction activities, and aerobic fermentation sludge has better improvement effect. MBN and key enzyme activities had significantly positive correlation with organic matter, nitrogen and phosphorus nutrients; Cr, Ni, Zn, As, Cd elements, and dehydrogenase activity would be inhibited by As element.The effects of different treated sludge on soil remediation in abandoned mining area can be evaluated by comparing the characteristics among sludge, especially the fractions of heavy metals and microbial characteristics. Aerobic fermentation stabilized sludge can be used as a good organic matrix for improvement of abandoned mining areas soil, through the synergistic effect of sludge resource utilization and ecological remediation of abandoned mining areas to solve the problem of local sludge pollution problems and meet the needs of abandoned mining areas soil remediation .

Keywords: Abandoned mining area; Soil matrix improvement; Stabilized sludge; Heavy metals speciation; Microbial characteristics

PP-116

The contribution of lignocellulosic constituents to Cr(VI) reduction capacity by biochar-supported zerovalent iron

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Biochars (BCs) derived from individual and blending lignocellulosic constituents were prepared to harbor zerovalent iron (ZVI/BC) in an effort to discriminate significance of each constituent or combination in ZVI/BC for Cr(VI) removal. BCs and ZVI/BC were characterized by TGA/GSC, XRD, Raman and BET analyses. Cellulose (BC_C) and hemicellulose (BC_H)-derived BCs has greater C content, H/C ratio, surface area and mass loss than BCs derived from lignin or lignin-containing biopolymer blends (BC_{LX}). As per sorption and XPS analysis, ZVI/BC demonstrated tremendously greater Cr(VI) removal capacity than respective BCs, in which reduction accounted for over 77% Cr(VI) detoxification. Cr(VI) reduction by ZVI harbored by BC_C and BC_H was 19.69-17.38 g kg^{-1}, compared to 7.01-5.47 g kg^{-1} for BC_{LX}. ZVI/BC prepared by three-biopolymer blends with (14.17 g kg^{-1}) or without (13.83 g kg^{-1}) mineral approximated pinewood-BC (BC_P) (14.32 g kg^{-1}) for Cr(VI) reduction, suggesting minerals are not important constituent. Tafel analysis showed BC_C and BC_H, with lower I_D/I_G ratio owing to greater graphitization, were more conducible to transfer electron of ZVI in Cr(VI) reduction than BC_{LX}. Thus, cellulose, hemicellulose and lignin can offer a good prediction of property of natural biomass, in which BC_C and BC_H favor electron transfer of ZVI but BC_L is not electroactive.

Keywords: heavy metals, biochar, zerovalent iron, soil and water remediation, biomass, electron transfer

PP-117

Preparation of highly-conductive pyrogenic carbon-supported zero-valent iron for enhanced Cr(VI) reduction

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In this work, electron transfer (ET) moiety of PC was ascertained in chromate (Cr(VI)) reduction by zero-valent iron supported by pyrogenic carbon (PC) (ZVI/PC) prepared by pyrolysis of hematite (α-Fe_2O_3)-treated pinewood. X-ray diffraction analysis suggested successive phase transformation of α-Fe_2O_3→magnetite (Fe_3O_4)→wustite (FeO) →ZVI (Fe^o). Raman spectra and Brunauer–Emmett–Teller analysis revealed that ZVI/PC is characterized with more ordered graphitic carbon and greater surface area than pristine PC. Maximal Cr(VI) removal capacity (pH=3) as predicted by Langmuir isotherm model were 5.78, 36.12 and 8.39 g kg^{-1} for PC, ZVI/PC and ZVI, respectively. ZVI/PC maintained significantly greater Cr(VI) removal capacity than ZVI and PC at pH 3-9, but Cr(VI) removal dropped rapidly to 6.78 g kg^{-1} at pH 4 and above. X-ray photoelectron spectroscopy and successive desorption of Cr-laden ZVI/PC and ZVI showed trivalent Cr was the dominant species, suggesting reduction was an important mechanism for Cr(VI) detoxification. Electrochemical analysis demonstrated that ZVI/PC exhibited greater Tafel corrosion rate and ET quantity, with lower electrical resistance. Besides, Cr(VI) reduction showed reversal trend with electrical resistance of ZVI/PC. To conclude, ET capacity was closely associated with electrical conductivity of ZVI/PC due to intensified conductive graphitic carbon structure of PC at higher pyrogenic temperatures.

Keywords: Pyrogenic carbon; Heavy metals; Soil remediation; Co-pyrolysis; Electron transfer

PP-118

Effects of elevated CO_2 on the bioavailability, uptake and translocation of the co-contaminated heavy metal(loid)s in the soil-rice (Oryza sativa L.) system

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The global climate change and soil heavy metals pollution have aroused widespread concern. There are also serious global challenges in grain security caused by heavy metals pollution and climate change. Rice pot experiments were established for full growth period at ambient (400 ppm) or elevated (600 ppm) CO_2 concentration in OTCs (open-top chambers) system to investigate the contamination features and bioavailability of heavy metal(loid)s (Cd, Pb, As) in naturally co-contaminated paddy soil and their uptake and translocation in rice. The results showed that elevated CO_2 concentration and heavy metal stress both affected the growth and development of plants, and elevated CO_2 relieves the stress of heavy metal(loid)s pollution on plant growth. Elevated CO_2 increased the net photosynthetic rate of rice leaves by 26%($P<0.05$) in the metal(loid)s pollution treatment, then increased the biomass of rice roots, stems, leaves and grains by 12.15%, 24.26%, 22.84% and 33.37%, respectively($P<0.05$), compared to ambient CO_2. Furthermore, Elevated CO_2 decreased soil pH and the iron plaque formation on rice root surface, but increased soil Eh value, these in turn affected the bioavailability of metal(loid)s in soil and uptake by rice plant. Elevated CO_2 increased the $CaCl_2$-extractable Cd and Pb in paddy soil, but decreased the $NH_4H_2PO_4$-extractable As in soil. Elevated CO_2 significantly increased Cd and Pb accumulation in rice grains by 18.74% and 35.35%, respectively, however reduced As uptake by rice plant. But no significant differences were found in the accumulation of As in rice grains. Ecological environmental risk assessment suggested that elevated CO_2 increased the environmental risk of Cd and Pb, but decreased the environmental risk of As. Therefore, food safety issues caused by heavy metals, especially by Cd, As, and Pb, under future climate change scenarios should be paid great attention.

Keywords: Elevated CO_2, heavy metals, bioavailability, translocation, soil-rice system

PP-119

Evaluation of the passivator remediation effect score in Cd contaminated soil

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Highly effective, economical, and replicable ways of Cd-polluted soil passivator are urgently needed now. A large number of human and material resources have been invested in the study to develop Cd polluted soil passivator. At present, heavy metal Cd passivation technology has achieved some stage results. But it still is a difficult problem to judge which passivator has better effect. There are relatively few studies in this area. Hence, this study begins to a research about evaluating passivator. It is decided to evaluate the repair effect of passivator by 0-1 score. The closer the score is to 1, the better the repair effect is, and vice versa. The whole research process is divided into five stages. Firstly, the indexes of evaluating are selected. Secondly, the importance degree (weight coefficient) of each index is determined, and then the basis of scoring is sorted out. Forth, the results of previous studies are combined for scoring (multi-objective weighting). Finally, we input the relevant index parameters, and evaluate and analyze the result by score. Sum up, the research results reveal that it is an appropriate way to evaluate the remediation effect of Cd-polluted farmland soil passivator in the form of score.

Keywords: Cd contaminated soil, Passivator, Evaluation system, AHP

PP-120

A pilot study of arsenic removal from water by biochar electrodes

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Arsenic, which is abundant in nature, is an element with a gray luster and has both metallic and nonmetallic properties. Arsenic pollution is mainly caused by As(III) and As(V), and As(III) is more toxic than As(V) and is more susceptible to oxidation. The rapid development of human society has resulted in the abundance of arsenic in natural waters. To date, several methods have been proposed to remove arsenic according to different situations: coagulation, biological treatment, ion exchange, adsorption, membrane treatment, etc. Cost, efficiency and secondary pollution are the challenges that these technologies need to face. It is of great significance to seek new methods that are green, efficient and economical. In this study, a new approach that using biochar electrode for arsenic removal was proposed, which reduces the cost and ensures the principle of environmental protection. When the concentration of arsenic was 0.05 mg /L, the adsorption efficiency of biochar was 12.8 %. At low concentration, the adsorption of arsenic by biochar conforms to the H-type adsorption isotherm. Under the same conditions, when a 10 V voltage was applied, the adsorption performance of biochar was significantly enhanced to 24.3%. Even when the applied voltage was increased to 30 V, the removal efficiency of arsenic reached 61.2%. The adsorption of arsenic by biochar was obviously improved by applied electric field. This may be due to the concentration of arsenite ions towards the anode under the influence of electric field, which increases the concentration gradient, thus increasing the adsorption rate of biochar. Moreover, the positive charge on the surface of anode biochar increases its adsorption affinity to anions, thus increasing its adsorption capacity. Therefore, the application of biochar electrode to remove arsenic from water is a new idea worthy of attention.

Key Words arsenic pollution; biochar adsorption; biochar electrode; enhancement

PP-121

Diversity of antimicrobial resistance genes and heavy-metal resistance genes in *Pseudomonas aeruginosa*

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The increase of antibiotic resistance genes (ARGs) showed a positive correlation with that of heavy-metal resistance genes (HRGs). While the evolutionary mechanism of those two types of genes is unclear. *Pseudomonas aeruginosa* is a common encapsulated, Gram-stain-negative, rod-shaped bacterium that is considered to be an opportunistic pathogen causing disease in plants and animals, including humans. *P. aeruginosa* is distributed widely in soil, water, skin flora, and most man-made environments throughout the world. Massive genomic data of *P. aeruginosa* facilitated to investigate diversity of ARGs and HMGs in this prokaryotic group. In this study, 209 high-quality complete genomes of *P. aeruginosa* were selected from NCBI RefSeq database to perform an investigation of distribution, diversity and evolutionary history of ARGs and HRGs. These genomes showed sizes of 6.16-7.76 Mbp and GC contents of 65.1-66.8%. Genomic annotations revealed that each *P. aeruginosa* strain encoded 5,712-7,396 genes, in which 58-72 ARGs and 42-50 HRGs were detected. Comparative genomic analysis indicated that those *P. aeruginosa* strains harbored 58,610 orthologous clusters (OCs), among which 68-87 ARG OCs and 57-72 HRG OCs were found. Variuos ARGs and HRGs were present in the genomes of *P. aeruginosa*, providing a broad view to elucidate their evolutionary history and relationship in the future study.

Key words: *Pseudomonas aeruginosa*, antibiotic resistance genes, heavy-metal resistance genes, comparative genomes

PP-122

Various effects of solar energy development on trophic transfer of heavy metals in food webs of irrigation-pond wetland ecosystems

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Irrigation ponds are artificial ponds, widely built in Taiwan >200 years ago, serving a primary function for agricultural irrigation. In Taoyuen county, total area of irrigation ponds (~26.7 km^2) makes up of 4% of total land area Taoyuen Plateau (758 km^2). There are >2000 irrigation ponds which were connected by extensive irrigation channels, forming a complicated network of wetland ecosystems providing important habitats for wildlife and many ecological functions such as water supply, farming and fishery supporting, water purification, climate regulation. However, under the “2025 Nuclear-free country” policy of Taiwan Government, green energy has extensively developed aiming to replace traditional nuclear power for electricity generation before 2025. Under such circumstance, solar panels have been installed on many irrigation ponds since 2018 with the target of modifying 54 irrigation ponds contributing to solar energy development and each pond with solar panels covering 60% of water surface area. Despite solar energy development could help to provide alternative source of power supply, it could cause various ecological impacts to the irrigation pond ecosystems during construction and operation stages. To better understand the impacts of solar energy development on the potential release of heavy metals and the trophic transfer of heavy metals in food webs of irrigation-pond wetland ecosystems, we investigated the effects of habitat biogeochemistry and food web structure on the heavy metal bioaccumulation and biomagnification of the dominant trophic predators, i.e. fish, in photovoltaic-panels covered and undisturbed irrigation ponds. Results showed that the ambient concentration of heavy metals Al, Fe, Cu, Ga, and Cd in water, and the bioaccumulation and biomagnification pattern in one of the common fish species *Oreochromis sp.* (Tilapia) were not consistent, but differences in their metal bioaccumulation levels between undisturbed ponds and photovoltaic-panels covered ponds. Our findings on the evaluation of the ecological effects of solar energy development in irrigation-pond wetland ecosystems will be further discussed.

Keywords: solar farm, wetlands, bioaccumulation, biomagnification

PP-123

Hydrological cycling of heavy Metals in subsurface groundwater of Kirana Hill Region Rabwah, District Chiniot, Pakistan

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The present study has been undertaken having an objective to evaluate the heavy metals concentration on groundwater quality as most of population in Rabwah town, Pakistan. The area is highly depending on groundwater sources for drinking purpose. A detailed analysis was piloted to understand the contamination level and distributions of heavy metals specifically Lead, Cadmium, Zinc, Nickel and transitional metal Iron in drinking water during winter and summer. Twenty-five surveyed private wells sites located in Precambrian Kirana hills region used to map the groundwater quality and assess its suitability for drinking purposes. Detected amount of lead, cadmium and nickel were found higher than World Health Organization Standard maximum permissible limits whereas the Ni levels were observed lower than the acceptable limit in some of the samples in summer. Generally, the mean metal concentration in sampled water sources have a descending order Ni>Pb>Cd>Zn>Cr in winter while Ni>Zn>Pb>Cr>Cd> Fe in summer. Water samples were highly enriched with Ni and Cr during summer and by Pb, Cd and Zn in winter. Further analysis of cereal grains also showed the presence of heavy metals in grain. The quality of the drinking groundwater sources was observed unsafe for drinking as well as for agriculture; moreover, there is still need to take proactive measures to check the levels of heavy metals. The spatial analysis and distribution of groundwater quality in Rabwah town will make it easier for authorities and decision makers to measure the groundwater quality and recommend most suitable location for boring wells in future.

Key words: Heavy Metal, Contamination, Atomic Absorption Spectroscopy, GIS Mapping, Seasonal Variation

PP-124

A new understanding of skin as an indicator for human exposed to Methylmercury

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Developing indicators for human exposure to methylmercury (MeHg) is critical in assessing health risk of MeHg. A number of indicators, including hair, EDI (estimated daily intake), urine, and nail, have been commonly used to assess human exposure to MeHg during short (e.g., days) or mid-term (e.g., months) period, but little is known about indicator for long-term (e.g., years) exposure to MeHg. The objectives of this study are to (1) try to validate a new indicator, i.e., dermal tissue, to assess long-term dietary exposure to MeHg; (2) explore the relationships among hair, dermal tissue and EDI. The validity of the indicator was examined by correlating MeHg levels in tissue samples (human skin and hair) collected from a hospital of 144 patients (ages ranged from 17 to 68 years old) and their dietary exposure to MeHg. Given that the growth rate of hair is 1cm/month, it is divided into different groups to indicate different exposure time. Methylmercury concentrations in tissue samples were determined, while dietary exposure to MeHg was assessed by questionnaire survey (to obtain ingestion rates for fish and rice, the two principle dietary sources of MeHg for Chinese). The average MeHg concentrations of skin and hair were 3.27±3.65 ng/g and 237.99±155.88 ng/g, respectively. Methylmercury levels in hair in this study were significantly lower than those in contaminated areas of southwestern China. To our knowledge, this was the first time that MeHg levels in skin has been reported. Both hair and skin tissues are equally sensitive to MeHg intake. According to Pearson correlation coefficients, MeHg contents in 6cm-12cm hair were significantly correlated with total MeHg EDI (fish EDI + rice EDI), i.e. MeHg EDI might stand for mid-term (up to 12 months) MeHg exposure. Methlymercury contents in >24cm hair had significant relationship with those in human skin, i.e. skin might indicate long-term (more than 2 years) MeHg exposure. The indicator validated in this study would help indicate long-term dietary exposure to MeHg, and especially identify sources of MeHg exposure for human beings.

Keywords: Methylmercury; bioindicator; dietary exposure; hair; human skin

PP-125

A novel 3d-hydrodynamic model of marine mercury speciation, cycling, and bio-accumulation

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Five decades of Hg science have shown the tremendous complexity of the global Hg cycle. Yet, the pathways that lead from anthropogenic Hg emissions to MeHg exposure through sea food are not fully comprehended. Moreover, the observed amount of MeHg in fish exhibits a large temporal and spatial variability that we cannot predict yet. A key issue is that fully speciated Hg measurements in the ocean are difficult to perform and thus we will never be able to achieve a comprehensive spatial and temporal coverage. Therefore, we need complex modeling tools that allow us to fill the gaps in the observations and to predict future changes in the system under changing external drivers (emissions, climate change, ecosystem changes). Numerical models have a long history in Hg research, but so far have virtually only addressed inorganic Hg cycling in atmosphere and oceans. Only in recent years, has the modeling community begun to develop the first marine models for mercury cycling in the ocean. Here we present a novel 3d-hydrodynamic mercury modeling framework based on fully coupled compartmental models including atmosphere, ocean, and ecosystem. Thus, to our knowledge, it is the first hydrodynamic mercury model to include a full ecosystem component. The generalized high resolution model has been set up for European shelf seas and was used to model the transition zone from estuaries to the open ocean. Based on this model we present our findings on intra- and inter-annual dynamics and variability of mercury speciation and distribution in a highly productive coastal ocean. Moreover, we present the first results on the dynamics of mercury bio-accumulation from a fully coupled marine ecosystem model. Most importantly, the model is able to reproduce the large variability in methylmercury accumulation in higher trophic levels.

Keywords: modeling, marine ecosystem, methylmercury, bio-accumulation

PP-126

Sulfur self-doped porous carbon derived from high inorganic sulfur coal as a promising material for highly efficient mercury capture

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Sulfur self-doped porous carbon was successfully derived from high inorganic sulfur coal (ZY coal) by KOH chemical activation method. Under the activated temperature of 800 °C and KOH/coal (mass ratio) of 2:4, the prepared sorbent has excellent performance of mercury removal. The specific surface area of this sorbent (ZY-2:4-800) can reach 353 $m^2 \cdot g^{-1}$, and the sulfur content is 0.92%. The iron sulfide compounds in coal can be converted into active sites for mercury removal during the preparation of the sorbent. The sorbent has a wide temperature window for mercury removal, and oxygen can improve its efficiency. At N_2+O_2 and the temperature of 120 °C, the equilibrium Hg^0 adsorption capacity of ZY-2:4-800 (inlet Hg^0 concentration of 307.9 $\mu g \cdot m^{-3}$) is greater than 214.71 $\mu g \cdot g^{-1}$. Compared with the activated carbons reported in the literature, the ZY-2:4-800 is superior in Hg^0 adsorption capacity than the majority of ACs. Using other high-inorganic sulfur coals as raw material can also obtain mercury sorbents, which has approximately the same mercury removal performance as that of sorbents from ZY coal, in similar preparation process. In addition, in order to investigate the mercury removal mechanism of ZY-2:4-800, the sorbents are characterized by XRD, N_2 adsorption/desorption, SEM, Hg-TPD, and XPS technologies. Mercury exists on the sorbent mainly in the form of β-HgS (metacinnabar), the product from chemical adsorption of Hg. The results indicate that the high value-added product prepared from high inorganic-sulfur coal is a promising alternative for removal mercury from flue gas of power plant.

Keywords: high inorganic sulfur coal, sulfur-doped porous carbon, mercury removal, flue gas, sorbent

PP-127

Adsorption of Heavy Metals by Natural and Oxidized Humic Acids

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Modern technologies for cleaning the environment from heavy metal pollution require the development and application of qualitatively new and effective materials characterized by increased absorption capacity, selectivity and environmental friendliness. Humic substances can serve as environmentally benign and inexpensive adsorbents of toxic heavy metals in the environment Purposeful chemical modification of humic acids can change their composition and increase the content of the necessary functional groups and thereby improve their heavy metal sorption properties. The adsorption of some heavy metals (Pb, Zn, Cu, and Ni) by natural and potassium persulfate oxidized humic acids isolated from a peat was investigated. The adsorption of the studied metals by the natural humic acids was satisfactorily described by the Langmuir isotherm model with maximum monolayer adsorption capacities of 318.2, 286.5, 225.0 and 136.8 mmol/kg for Pb, Cu, Zn and Ni, respectively. A thorough characterization of the natural and modified HA using 13C nuclear magnetic resonance spectroscopy demonstrated that the chemical modification of natural humic acids with potassium persulfate led to an increase in the number of carboxyl groups, and ketone and quinoid fragments in the acids structure. Consequently, the oxidized humic acids adsorbed 16.3, 14.2, 10.6 and 6.9% more Pb, Ni, Zn and Cu, respectively, than the initial natural organic matter. The isotherm data modelling together with adsorbent characterization suggested that the adsorption of heavy metals was controlled mainly by chemisorption mechanisms where inner-sphere complexations of metal ions with himic acid functional groups took place.

The study was supported by the Russian Foundation for Basic Research (Project No. 18-04-00274).

Keywords: trace elements, humic substances, adsorption, persulfate oxidation

PP-128

The effect of potassium fertilizer on the bioavailability and ecotoxicity of Thallium-contaminated flooded paddy soils

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Thallium (Tl) is a priority pollutant with high toxicity and exposure risk. With rapid development of high-tech industries, technology-critical elements such as Tl could be released into the paddy soils via use of manufacturing wastewater as irrigating water sources for rice culture. The Tl occurrence in contaminated paddy soils was detected in previous studies; however, the pollutant transportation, bioavailability and eco-toxicity of Tl in contaminated paddy field are less known. In this study, we aim to use medaka fish as a model organism to assess the bioavailability and toxicity in Tl-contaminated paddy soil. We selected three different soil series to establish a flooded soil system, artificially spiked with Tl. Experiments were performed by twice 7-day medaka fish exposures to measure Tl and K concentration changes in overlying and pore water of exposed systems and fish toxicity. We aim to assess the relationship between soil properties and mobility of thallium, and the effect of Tl-induced toxicity in soil system after potassium fertilizer application. The results showed when soil had lower pH value, the mobility and solubility of Tl in soils were higher. However, the effects of other soil properties on Tl release could not be seen. Besides, the exchangeable potassium in exposed system could reduce the toxicity caused by Tl, but the mitigation capacity of potassium was limited. This may be ascribed to that potassium ions could cause the more replacement of Tl in soils, resulting the more release of Tl to increase the toxicity. Subsequent research will continue to explore the distribution of Tl in different environmental soils and the association of toxicity and bioavailability.

Key word: Thallium; paddy soil; bioavailability; medaka fish; toxicity; potassium fertilizer

PP-129

Flow-through experiments to evaluate leaching, bioavailability and fractionation of Cd in three contaminated soils amended with various organic, inorganic and composite amendments

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Present study reports two consecutive leaching experiments to assess the immobilization efficiency of ten treatments in three moderately cadmium (Cd) contaminated soils (Stagnic anthrosol: S1, Gleysol: S2 and Fluvisol: S3). Maximum reduction in the Cd concentration in the leachate was noted therefore, three treatments (T2, T5 and T10) were further investigated for metal immobilization, extraction and fractionation in high contamination (1 and 2 mg kg^{-1}). Obtained results revealed that the amendments significantly reduced the leachate metal contents in 1 mg kg^{-1} spiked soils. SEM characterization of T2, T5 and T10 revealed their structural transformations in all soil types while active functional groups e.g. C-O, C=O, O-H, Si-O-Si and ester and alcoholic groups were notably involved in Cd precipitation, complexation or adsorption on amendments surface. Changes in Cd speciation in soils exhibited the Cd exchangeability to more stable fractions with applied additives. These continuous-flow experiments confirm the efficiency of lime, biochar and composite amendment in reducing the metal concentration in leachate but further investigations regarding their long-term stability prior to large scale application are needed. This study has strong implications in understanding the role of different amendments in controlling the fate, leaching behavior and immobilization of Cd in diverse soil types.

Keywords: Cadmium, Organic amendments, Inorganic amendments, Cd fractionation

PP-130

Differentiation of digestion method for heavy metals in river sediments based on organic matter gradients

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Heavy metal detection in river sediments is the basis to evaluate heavy metal pollution level, risk and control in river sediments. However, most of existing detection methods have low recovery rate and high total acid consumption. Considering continuous accumulation and relative high content of organics in river sediments, this paper focused on studying differentiated digestion method of heavy metals based on organics gradient grading. Firstly, surface river sediment samples were collected from 26 different rivers and lakes within the Qiantang River basin (e.g. Hangzhou and Jiangxing). Organic matter content in these samples were tested and these samples were divided into 8 groups according to content of organic matter. Later, the effect of hydrochloric acid, nitric acid and hydrofluoric acid in the digestion system on digestion of heavy metals (Cu, Zn and Ni) in 8 different sediments grouped by TOC content was discussed respectively. And then the optimum digestion system of heavy metals in river sediments based on organic matter gradients was established. Results demonstrated that this digestion system achieves high recovery rate (90%~110%) and accuracy at an average total acid consumption of 10.54mL, less than that of the Chinese standard digestion method (19mL). This means that the digestion system proposed in this paper is environmentally friendly.

Keywords: heavy metal, river sediments, TOC

PP-131

Thermal stress-induced lead (Pb) toxicity on apoptotic cell death, inflammatory response, oxidative defense, and DNA methylation in zebrafish (Danio rerio) embryos

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Lead (Pb) is a toxic environmental pollutant that is frequently present in effluents from urban, mining, and industrial sources. The combinatorial effects of heavy metal exposure and temperature in aquatic organisms have received considerable attention as heat stress occurs simultaneously in conjunction with several contaminants in a natural environment. In this study, we examined the potential effects of Pb exposure in conditions of thermal stress (34 °C) in zebrafish (Danio rerio) embryos. Thermal stress at 34 °C induced a dramatic decrease in the survival rate, although exposure to Pb at 26 °C decreased the survival rate of the embryos. Malformations, such as the curved body shape, were increased in response to exposure to a combination of Pb and heat stress. The combination of Pb and heat stress also caused a decrease in the heart rate. Moreover, Pb and high-temperature exposure induced the upregulation of SOD, CAT, TNF-α, IL-1β, p53, and BAX transcripts, and downregulation of Dnmt1 and Dnmt3b transcripts. Thermal stress enhanced transcriptional responses of eight indicator genes following Pb toxicity. The induction of cell death in response to combined exposures was also confirmed in the body of zebrafish by fluorescence intensity image analysis. These data indicated that thermal stress enhanced the poisonous effects of Pb exposure on antioxidant defense, inflammation, and apoptotic mechanisms. Transcriptional inhibition of DNA methylation-related genes might serve as a crucial factor contributing to the possibility of epigenetic adaptation by altering combined stress. We suggest that a careful evaluation of the potential effects of climate change (especially temperature) should be considered when investigating the toxic levels of metal pollution, such as Pb, in an aquatic environment.

Keywords: Heavy metal, Temperature, Inflammation, Apoptosis, DNA methylation

PP-132

Effect of plastic mulch and drought on metal contaminated soils in farmland

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Application of plastic mulch has multiple benefits for agriculture. However, the release of plastic debris from mulch is a serious problem in farmland. There is a prompt need to understand the effects of plastic mulch on agricultural soils. In addition, climate change during a few decades has accelerated occurrence of drought in farmland. The objective of this study is the investigation about effect of plastic mulch on contaminated soil with heavy metals by building up soil microcosms in drought conditions. Metal-contaminated soils were sampled from an upland fallowed field adjacent to historical mining area and added 1% (w w^{-1}) plastic mulch in which there was no noticeable visual change on soils. Treated soil were incubated at 30% of water holding capacity indicating water content that crops are wilted by drought. After 100 d, the change in soil physicochemical and biological properties was evaluated. The mobility and availability of heavy metals were also tested in plastic mulch treated soils under drought condition. This work was carried out with the support of "Cooperative Research Program for Agriculture Science and Technology Development (Effect of plastic mulch wastes on crop productivity and agro-environment, project no. PJ01475801)" Rural Development Administration, Republic of Korea.

Keywords: plastic mulch, drought, soil properties, heavy metals, availability

PP-133

Effects of phosphorous application on the accumulation of inorganic As in *Brassica chinensis* grown in As-contaminated soils

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Arsenic (As) is human carcinogen, and the intake of As through crop consumption may lead to adverse health effects, thus the reduction of As uptake by crops has become an important issue. Recently, it has been reported that the high accumulation of As in leafy vegetables grown in As-contaminated soils. However, compared with paddy rice, previous studies related to the mechanism of As accumulation in leafy vegetables is still limited. Therefore, the object of this study is to investigate the effects of phosphorous (P) application on the accumulation of As in *Brassica chinensis* grown in As-contaminated soils with different soil characteristics. A pot experiment was conducted and five Pi treatments (0, 1, 2, 5 and 10 folds of recommended amount of P (RAP) fertilizer) were each applied to two tested soils (Gd and Ms) with two As levels. The results indicate that the concentration of P in shoot of *Brassica chinensis* increased with RAP in soils, this trend was consistent with As concentrations in shoot of *Brassica chinensis* grown in Ms soils (low-As retention capability). However, it found that the accumulation of As in shoot of *Brassica chinensis* were significant decreased in Gd soils (high-As retention capability) under the treatment of 5 and 10 folds of RAP, which may resulted from competitive absorption between As and P in the plant of *Brassica chinensis*. In addition, it also found the predominant As species in edible part of *Brassica chinensis* was inorganic arsenite and arsenate, and the percentage of arsenite was higher than 80% of total As. Therefore, the results of this study suggest that the accumulation of inorganic As in the shoot of *Brassica Chinensis* determined by the P application rates and soil properties.

Keywords: Inorganic arsenic, leafy accumulation, phosphate fertilizer, *Brassica chinensis*

PP-134

Impact of different amendments on dietary toxicity of arsenic in two rice genotypes in paddy soil-rice system

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Rice is the staple food for more than half of the world's population. Hypoxic or anaerobic conditions in paddy soils can have a profound influence on As availability to plants through shift in As speciation (arsenate to arsenite) and its strong capacity of rice to absorb As from soil and transport it to shoots and grain. However, it remains unexplored how different organic and inorganic amendments could affect As accumulation in the two contrasting rice genotypes. Here, we explored the accumulation of As in different parts of rice plants of two rice genotypes (Kainat and Basmati-385; i.e., fine and coarse varieties, respectively). Various materials including the farm yard manure (FYM), cow dung (CD), biogas slurry (BGS), biosorbent (Bios) gypsum, lignite were applied to determine their impact on soil As uptake by the rice plants in a pot experiment. Arsenic-contaminated irrigation water was applied to rice plants after 20 days of transplantation at three intervals during the experiment: one at transplanting stage; second at booting stage; and third at reproductive stage. Results revealed that shoot length, root length and total biomass of the Kainat and Basmati-385 genotypes were significantly higher in CD and FYM applied treatments compared to control. Arsenic concentration in the plant roots, shoots and grain ranged from 60–171, 5.2–46 mg/kg DW, respectively, compared to control treatment for both the rice genotypes. The translocation factor (TF) spanned 0.07 to 0.51 with the minimum values obtained for CD and Bios treatments in both the rice genotypes (TF: 0.07 and 0.29). This study shows that the organic amendments, particularly FYM, CD and Bios, have the ability to reduce As accumulation by the rice genotypes investigated here, although Kainat possessed the minimum grain As content, and as such could be suitable for assessment under the field conditions in the remediation of As-contaminated paddy soils.

Keywords: Arsenic, Health risk; Organic, and inorganic amendments, Rice genotypes

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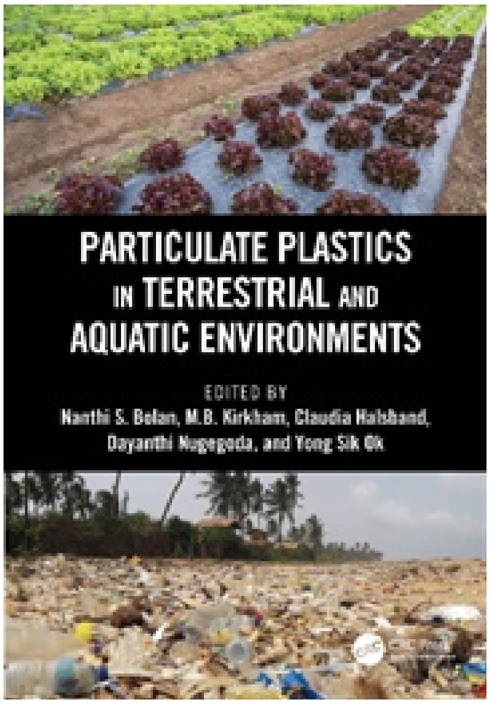
Particulate Plastics in Terrestrial and Aquatic Environments



Edited By Nanthi S. Bolan, M.B. Kirkham, Claudia Halsband, Dayanthi Nugegoda, Yong Sik Ok

eBook Published: 30 July 2020
Pub. Location: Boca Raton
Imprint: CRC Press
DOI: https://doi.org/10.1201/9781003053071
Pages: 466 pages
eBook ISBN: 9781003053071
Subjects: Bioscience, Environment & Agriculture

The manufacture of plastic as well as its indiscriminate disposal and destruction by incineration pollutes atmospheric, terrestrial, and aquatic ecosystems. Synthetic plastics do not break down; they accumulate in the environment as macro-, micro-, and nanoplastics. These particulate plastics are a major source of pollutants in soil and marine ecosystems. Particulate Plastics in Terrestrial and Aquatic Environments provides a fundamental understanding of the sources of these plastics and the threats they pose to the environment. The book demonstrates the ecotoxicity of particulate plastics using case studies and offers management practices to mitigate particulate plastic contamination in the environment.

Key Features:

- Describes physical and chemical properties of particulate plastics in terrestrial and aquatic ecosystems
- Presents information on characteristics of particulate plastics as impacted by weathering processes
- Provides numerous approaches for managing particulate plastic contamination
- Identifies sources of particulate plastics in the environment; distribution and characteristics of particulate plastics; and management strategies of particulate plastics

Written by a global team of scientists, this book is for researchers in the fields of environmental safety and waste management or individuals interested in the impact of particulate plastics on environmental health.

Association of Pacific Rim Universities
Sustainable Waste Management

Program Leaders

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Introduction and overview of the APRU Sustainable Waste Management Program

Waste such as food waste, yard waste, agricultural waste, sewage sludge, industrial waste, and e-waste imposes critical burdens on the environment, consuming precious land resources, and aggravating global warming. Currently, waste management has become a major challenge for most countries throughout the world. Deposition of waste in residential areas, uncontrolled landfills, illegal dumping of waste to waterways, and marine environment results in severe land, water, and air pollution causing tremendous negative impacts not only for humans but also for floral and faunal diversity in ecosystems. Hence, the development of sustainable waste management strategies has become a major concern throughout the world. Thus, this program focuses on “recycling” and “recovery” of waste material while paving the way towards soil remediation, land remediation, and groundwater remediation with water and wastewater treatments.

This program will offer a timely opportunity for knowledge exchange among professionals all over the world to assist the formulation of an efficient sustainable management agenda for organic waste and remediation of soil, land, and groundwater in the local context, which satisfies the environmental compatibility, financial feasibility, and social needs. It will deliberate on state-of-the-art treatment technologies, advanced management strategies, and political issues pertaining to recycling and recovery of organic waste.

Moreover, local and overseas experts from different sectors including academic researchers, industrial practitioners, green groups, and government departments will be gathered in this program to solicit scientific and technical inputs as well as political feedback, facilitating the development of integrated solutions. Experienced industrial practitioners, professional organizations, green groups, as well as government officers are invited to the conference.

The program will be hosted by the Korea University (Seoul, Korea) together with APRU and supported by APRU member universities as well as non-APRU universities including Stanford University in USA, Nanyang Technological University in Singapore, National University of Singapore in Singapore, University of Queensland in Australia, Chulalongkorn University in Thailand, Fudan University in China, University of Malaya in Malaysia, Nanjing University in China, The University of Sydney in Australia, National Taiwan University in Taiwan.

2nd Food Innovation and Engineering (FOODIE) Asia Conference

November 23-24, 2020
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The 2020 FOODIE Asia: Long Term Evolution for the Asian Food Economy will discuss strategic innovation and engineering for safe, sustainable food production and distribution that fits the consumer market and future needs.

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Australian Circular Economy Conference

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Australian Circular Economy Conference
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Unlocking value from waste resources through collaboration and technology

19-20 November 2018
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The inaugural 'Australian Circular Economy Conference' (ACEC) is organised by

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Seoul is a city where opposites sit comfortably alongside one another: gleaming skyscrapers stand in proximity to ancient Buddhist temples; artisan crafts jostle for attention with mass-produced pop music; and delicious meals can be purchased from Michelin-starred restaurants and modest street food stalls alike. It is a huge conurbation that feels minute because of the speed and reliability of its public transport system. The city has many contrasting faces that maximise its attractiveness. In particular, its vibrant nightlife brings into sharp focus the famous hard-working attitude displayed by Koreans during the daytime. Seoul attracts thousands of corporate travellers every year and they are charmed by South Korea's food, nightlife and culture.

Although you are far away from Seoul, you will be able to know about Korean culture and you can see many attractive places in Seoul such as Changdeokgung Palace which is one of the UNESCO world heritage site, Seoul Botanical Garden which is one of Seoul's representative unique venues, Namsan Seoul Tower through virtual Seoul MICE World .

We hope that you will enjoy the conference and you will not feel that you are away from us.

Virtual Seoul MICE World

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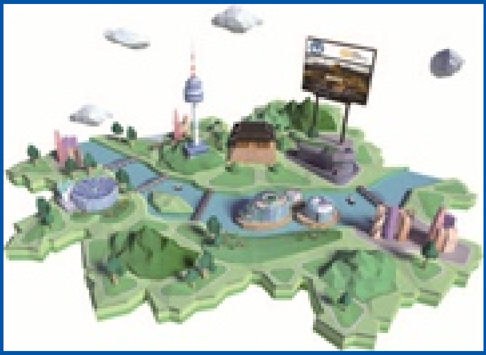

This work was supported by the Korean Federation of Science and Technology Societies (KOFST) grant funded by the Korean government.