2014 ANNUAL SHOWCASE FOR SOIL AND GROUNDWATER

International Conference on Remediation and Management of Soil and Groundwater Contaminated Sites

November 26-28

Taipei World Trade Center Nangang Exhibition Hall
(TWTC Nangang)

Taipei, Taiwan

Proceedings (Abstracts)

Contents

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Program
at a glance

Nov 26 (Wed)	08:00-09:30	Registration		
	09:30-10:00	**Opening Ceremony**		
	10:00-10:30	Coffee Break		
	10:30-11:20	**Plenary Session**: Keynote Speech 1 **Sustainable Development and Management of Brownfields** (Prof. Dr. Rao Surampalli)		
	11:20-12:10	**Plenary Session**: Keynote Speech 2 **Risk Based Contaminated Land Management** (Prof. Dr. Paul Nathanail)		
	12:20-13:30	Lunch		
	Room	**504-A**	**504-B**	**504-C**
	13:30-15:10	**S1: Sustainable Remediation (1)** Moderator: Dr. Shih-Cheng Pan (潘時正)	**S3: Remediation of Organic Pollutants (1)** Moderator: Prof. Dr. Gordon. C. C. Yang (楊金鐘)	**S5: Health Risk-based Remediation Technology (1)** Moderator: Prof. Dr. Lambert L. Ding (丁力行)
	15:10-16:00	Coffee Break & Poster Discussion		
	16:00-17:00	**S2: Sustainable Remediation (2)** Moderator: Dr. Shih-Cheng Pan (潘時正)	**S4: Remediation of Organic Pollutants (2)** Moderator: Prof. Dr. Gordon. C. C. Yang (楊金鐘)	**S6: Health Risk-based Remediation Technology (2)** Moderator: Prof. Dr. Lambert L. Ding (丁力行)
Nov 27 (Thu)	08:00-09:00	Registration		
	09:00-10:40	**S7: Sustainable Remediation (3)** Moderator: Prof. Dr. Colin S. Chen (陳士賢)	**S9: Remediation of Organic Pollutants (3)** Moderator: Prof. Dr. Ting-Nien Wu (吳庭年)	**S11: Sampling, Monitoring and Evaluation of site (1)** Moderator: Prof. Dr. Chitsan Lin (林啟燦)
	10:40-11:10	Coffee Break		
	11:10-12:10	**S8: Sustainable Remediation (4)** Moderator: Prof. Dr. Colin S. Chen (陳士賢)	**S10: Remediation of Organic Pollutants (4)** Moderator: Prof. Dr. Ting-Nien Wu (吳庭年)	**S12: Sampling, Monitoring and Evaluation of site (2)** Moderator: Prof. Dr. Chitsan Lin (林啟燦)
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Program
at a glance

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	15:10-16:00	Coffee Break & Poster Discussion		
	16:00-17:00		**S15: Remediation of Heavy Metals (2)** Moderator: Prof. Dr. Dar-Yuan Lee (李達源)	**S17: Sampling, Monitoring and Evaluation of site (4)** Moderator: Mr. Spock Huang (黃建源)
Nov 28 (Fri)	08:00-09:00	Registration		
	09:00-10:40	**S18: Bioremediation (1)** Moderator: Dr. Ming-Daw Che (車明道)	**S20: Remediation of Heavy Metals (3)** Moderator: Prof. Dr. Zeng-Yei Hseu (許正一)	**S22: Sampling, Monitoring and Evaluation of site (5)** Moderator: Prof. Dr. Shian-Chee Wu (吳先琪)
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	11:10-12:10	**S19: Bioremediation (2)** Moderator: Dr. Ming-Daw Che (車明道)	**S21: Remediation of Heavy Metals (4)** Moderator: Prof. Dr. Zeng-Yei Hseu (許正一)	
	12:10-13:30	Lunch		
	13:30-15:10	**S23: Bioremediation (3)** Moderator: Dr. Chih Huang (黃智)	**S24: Remediation of Heavy Metals (5)** Moderator: Prof. Dr. Yong Sik OK	
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	15:40-16:30	**Closing Ceremony**		

Plenary session

Detailed Program

November 26 (Wed)

Location: Room **504**

Time	Speaker	Topics	Page
08:00-09:30	Registration		
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09:35-09:40	Opening address by **Deputy Minster**, **Mr. Tzi-Chin Chang**		
09:40-10:00	Group photo		
10:00-10:30	Coffee Break		
10:30-11:20	**Prof. Dr. Rao Surampalli**	Keynote Speech 1 : **Sustainable Development and Management of Brownfields**	23
11:20-12:10	**Prof. Dr. Paul Nathanail**	Keynote Speech 1 : **Risk Based Contaminated Land Management**	24
12:10-13:30	Lunch		

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November 26 (Wed)

Room **504-A**

Session **S1**: **Sustainable Remediation (1)**

Moderator: **Dr. Shih-Cheng Pan** (潘時正)

Time	Speaker	Topics	Page
13:30-14:10	**Prof. Dr. Jonathan Smith***	**Sustainable Remediation: Incorporating sustainability into risk-based soil and groundwater management projects**	30
14:10-14:40	Pei-San Lee 李佩珊	**[SR-O-1]** Brownfields Screening, Redevelopment Planning and Prioritization Process Promoting in Taiwan	44
14:40-15:10	Andrew Pruszinski	**[SR-O-2]** Vapour (TCE) intrusion and the relocation of people from their homes – the cause, the relocation, the science, the outrage	45
15:10-16:00	Coffee Break & Poster Discussion		

Session **S2**: **Sustainable Remediation (2)**

Moderator: **Dr. Shih-Cheng Pan** (潘時正)

Time	Speaker	Topics	Page
16:00-16:40	**Mr. Jonathan Meier***	**Challenges in implementing groundwater remedial technologies in Asia with case studies from Japan: Permeable Reactor Barrier (PRB) and In-Situ Thermal Remediation (ISTR)**	29
16:40-17:10	Ben B.J. Shiau	**[SR-O-3]** Advances in Surfactant Enhanced Aquifer Remediation: Lessons Learned and New Trend	47

Detailed Program

November 26 (Wed)

Room **504-B**

Session **S3**: **Remediation of Organic Pollutants (1)**

Moderator: **Prof. Dr. Gordon C. C. Yang (楊金鐘)**

Time	Speaker	Topics	Page
13:30-14:10	**Mr. Jeffrey D. TeGrotenhuis***	**Containment and Bioreactor, Wetlands, or Ion Exchange Resin Ex-Situ Treatment to Facilitate In-Situ Remediation**	28
14:10-14:50	Chih Huang 黃智	**[RO-O-1]** Groundwater Circulation System for CVOC Contaminated Groundwater in Taiwan-Case Study	
14:50-15:10	Lo Tsui 崔珂	**[RO-O-2]** Applying Compost Liquid as Surfactant Flushing Agent for Enhancing Removal of Groundwater PCE	52
15:10-16:00	Coffee Break & Poster Discussion		

Session **S4**: **Remediation of Organic Pollutants (2)**

Moderator: **Prof. Dr. Gordon C. C. Yang (楊金鐘)**

Time	Speaker	Topics	Page
16:00-16:40	Khalilalrahman Dehvari	**[RO-O-3]** Degradation of TNT, RDX, and HMX Explosives using Permeable Zero Valent Iron Nanoparticles Barrier	53
16:40-17:10	Yu-Huei Peng 彭優慧	**[RO-O-4]** Adsorption and sequential degradation of brominated flame retardants with zerovalent iron	54

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November 26 (Wed)

Room **504-C**

Session **S5**: **Health Risk-based Remediation Technology (1)**

Moderator: **Prof. Dr. Lambert L. Ding (丁力行)**

Time	Speaker	Topics	Page
13:30-14:10	**Dr. Karin Guiguer***	**Ecological Risk Assessment under Canada Federal Contaminated Sites Action Plan - Steeves Lake, Colomac Mine Example**	33
14:10-14:50	**Dr. Rebecca Chou***	**Low-Threat Underground Storage Tank Case Closure Policy in California**	38
14:50-15:10	Hsien-Shiow Tsai 蔡顯修	**[HR-O-1]** The Improvement of Transformer Insulation Oil Pollution Site	60
15:10-16:00	Coffee Break & Poster Discussion		

Session **S6**: **Health Risk-based Remediation Technology (2)**

Moderator: **Prof. Dr. Lambert L. Ding (丁力行)**

Time	Speaker	Topics	Page
16:00-16:40	**Dr. Sophie Wood***	**Assessment of ecological risks in coastal sediments: An Australian oil refinery case study**	39
16:40-17:10	Huei-Shan Lin 林輝山	**[HR-O-2]** Establishment the system platform of risk management for abandoned factories in Taiwan	61

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Session **S7**: **Sustainable Remediation (3)**

Moderator: **Prof. Dr. Colin S. Chen (陳士賢)**

Time	Speaker	Topics	Page
09:00-09:40	**Mr. Marc Soellner***	**Green and Sustainable Remediation: A Review and an Outlook**	36
09:40-10:10	Tsai-Wen Chiang 蔣在文	**[SR-O-4]** Green and Sustainable Remediation Development in Taiwan	48
10:10-10:40	Sheng-Wei Wang 王聖瑋	**[SR-O-5]** Management of groundwater quality in Taiwan	49
10:10-10:40	Coffee Break		

Session **S8**: **Sustainable Remediation (4)**

Moderator: **Prof. Dr. Colin S. Chen (陳士賢)**

Time	Speaker	Topics	Page
11:10-11:50	**Dr. Dora Chiang***	**An Overview of the History, Accomplishments, and On-going Initiatives of the Sustainable Remediation Forum (SURF)**	25
11:50-12:10	Charley Wang 王從利	**[SR-O-6]** Imminent Environmental Remediation in China	50
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Room **504-B**

Session **S9**: Remediation of Organic Pollutants (3)

Moderator: **Prof. Dr. Ting-Nien Wu (吳庭年)**

Time	Speaker	Topics	Page
09:00-09:40	Yang-hsin Shih 施養信	**[RO-O-5]** Zerovalent iron nanoparticles for the remediation of recalcitrant organic contaminants	55
09:40-10:10	Kuen-Song Lin 林錕松	**[RO-O-6]** *In-Situ* Decontamination of DNAPLs in Groundwater by Polymer-coated Zero-valent Iron Nanoparticles	56
10:10-10:40	Chih-ping Tso 左致平	**[RO-O-7]** The reduction of hexabromocyclododecane (HBCD) by zerovalent iron and bimetallic nanoparticle aggregates	57
10:10-10:40	Coffee Break		

Session **S10**: Remediation of Organic Pollutants (4)

Moderator: **Prof. Dr. Ting-Nien Wu (吳庭年)**

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11:10-11:40	Chau-Yuan Wei 韋朝源	**[RO-O-8]** Decolorization and mineralization of Congo red with zerovalent iron nanoparticles	58
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Session **S11**: Sampling, Monitoring and Evaluation of site (1)

Moderator: **Prof. Dr. Chitsan Lin (林啟燦)**

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09:40-10:10	Shawntine Lai 賴宣婷	**[SME-O-2]** The Application of Multi-Increment Sampling to Characterization of Pb on Agricultural Land	66
10:10-10:40	Yi-Fong Pan 潘毅峰	**[SME-O-3]** Impact of natural organic matter on the redox reaction of arsenic in water	67
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Moderator: **Prof. Dr. Chitsan Lin (林啟燦)**

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11:40-12:10	Chia-Hsing Lee 李家興	**[SME-O-5]** Prediction of Cu and dissolved organic carbon (DOC) sorption onto kaolinite in field pH range	69
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Moderator: **Prof. Dr. Kuei-Jyum Yeh (葉桂君)**

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14:10-14:50	Huei-YA Lin 林徽雅	**[EF-O-1]** Identifying the Source of Heavy Metals Contaminated in Farmlands and Cases Sharing	78
14:50-15:10	Kai-Hsing Yang 楊愷行	**[EF-O-2]** Application of Geographic Information System to Soil and Groundwater Contamination Management	79
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Session **S14**: Remediation of Heavy Metals (1)

Moderator: **Prof. Dr. Dar-Yuan Lee (李達源)**

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14:10-14:50	Zeng-Yei Hseu 許正一	**[HM-O-1]** Effects of Remediation Train Sequence on Decontamination of Heavy Metal-contaminated Soil Containing Mercury	82
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Moderator: **Prof. Dr. Dar-Yuan Lee (李達源)**

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16:40-17:10	T. Y. Yeh 葉琮裕	**[HM-O-4]** The Improvement of Phytomediation on the Treatment Effectiveness of Heavy Metals with Energy Sunflower Plants with Calcium Peroxide and Phytohormones	85

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Moderator: **Mr. Spock Huang (黃建源)**

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14:10-14:50	Tsai-Ping Lee 李在平	**[SME-O-7]** Evaluation of Preferential Groundwater Flow Using the Heat-pulse Flowmeter at a Contamination Site	71
14:50-15:10	Yu-Jen Huang 黃裕仁	**[SME-O-8]** Evaluation of anaerobic reductive dechlorination of trichloroethene by using laboratory scale columns	72
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Moderator: **Mr. Spock Huang (黃建源)**

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November 28 (Fri)

Room **504-A**

Session **S18**: **Bioremediation (1)**

Moderator: **Dr. Ming-Daw Che (車明道)**

Time	Speaker	Topics	Page
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09:40-10:10	Chih-Jen Lu 盧至人	**[BR-O-1]** Aerobic Biodegradation of Dichloroethene in Simulated Groundwaters	92
10:10-10:40	Martin Slooijer	**[BR-O-2]** Biological Chlorobenzene Remediation	93
10:40-11:10	Coffee Break		

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Moderator: **Dr. Ming-Daw Che (車明道)**

Time	Speaker	Topics	Page
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11:40-12:10	Chin-Shun Kuo 郭進順	**[BR-O-4]** Biodegradation of 4-monobrominated diphenyl ether with anaerobic microcosms	95
12:10-13:30	Lunch		

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November 28 (Fri)

Room **504-B**

Session **S20**: **Remediation of Heavy Metals (3)**

Moderator: **Prof. Dr. Zeng-Yei Hseu (許正一)**

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09:00-09:40	**Prof. Jae E. Yang***	**Beneficial Use of Coal Combustion Residuals for the Sustainable Land Remediation in Korea**	27
09:40-10:10	Chia-Hsing Lee 李家興	**[HM-O-5]** The effects of adding husk on arsenic concentration of brown rice grown in two poor-drained arsenic-contaminated soils	86
10:10-10:40	Woo-Chang Kang	**[HM-O-6]** An Online Monitoring System using Sulfur Oxidizing Bacteria for Detection of Toxic Chemicals in Stream Water	87
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Moderator: **Prof. Dr. Zeng-Yei Hseu (許正一)**

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11:50-12:10	Gordon. C. C. Yang 楊金鐘	**[HM-O-7]** Remediation of an Actual Mercury-Contaminated Soil Using the Iodide-Assisted Electrokinetic Process	88
12:10-13:30	Lunch		

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November 28 (Fri)

Room **504-C**

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Moderator: **Prof. Dr. Shian-Chee Wu (吳先琪)**

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09:40-10:10	Ting-Nien Wu 吳庭年	**[SME-O-11]** Comparison of Membrane Interface Probe and Laser Induced Fluorescence on Site Pollution Investigation and Assessment	75
10:10-10:40	Chiling Chen 陳琦玲	**[SME-O-12]** Inorganic Nitrogen Distribution in Groundwater in Southwestern Taiwan and Strategies to Prevent Its Contamination	76
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Detailed Program

November 28 (Fri)

Room **504-A**

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Moderator: **Dr. Chih Huang (黃智)**

Time	Speaker	Topics	Page
13:30-14:10	**Dr. Kazuhiro Takagi***	**Recent progress in bioremediation study of POPs-contaminated soil**	34
14:10-14:50	Huifeng Shan	**[BR-O-5]** PeroxyChem's Chemical and Biological Remediation Technologies and Applications at Challenging Sites in China	96
14:50-15:10	Chitsan Lin 林啟燦	**[BR-O-6]** Application of Compost Tea for the Treatment of Diesel Contamination by Soil Washing	97
15:10-15:40	Coffee Break		
15:40-16:30	Closing Ceremony		

S23 (Day 3)

Detailed Program

November 28 (Fri)

Room **504-B**

Session **S24**: **Remediation of Heavy Metals (5)**

Moderator: **Prof. Dr. Yong Sik OK**

Time	Speaker	Topics	Page
13:30-14:10	**Prof. Dr. Yong Sik OK***	**The role of biochar, natural iron oxides and nanomaterials as soil amendments for immobilizing metals in shooting range soil**	40
14:10-14:50	Chiling Chen 陳琦玲	**[HM-O-8]** Arsenic distribution in groundwater in southwestern Taiwan and evaluation of removal methods	89
14:50-15:10	Chien-Hui Syu 許健輝	**[HM-O-9]** Effect of soil As concentrations and genotypes on As content and speciation in grains of rice grown in As-elevated paddy soils	90
15:10-15:40	Coffee Break		
15:40-16:30	Closing Ceremony		

S24 (Day 3)

Invited Speakers

Keynote Speakers

Sustainable Development and Management of Brownfields

Anushuya Ramakrishnan[1], Rao Y. Surampalli[2]*, Tian C. Zhang[2], R.D. Tyagi[3] and C.M. Kao[4]
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Abstract

Brownfields are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties protects the environment, reduces blight, and takes development pressures off green spaces and working lands. The Brownfields Program of the United States Environmental Protection Agency (EPA) empowers states, communities, and other stakeholders to work together to prevent, assess, safely clean up, and sustainably reuse brownfields. Revitalizing brownfield sites creates benefits throughout the community. Through fiscal year 2013, on average, $17.79 was leveraged for each EPA Brownfields dollar and 7.3 jobs leveraged per $100,000 of EPA Brownfields funds expended on Assessment, Cleanup, and Revolving Loan Fund cooperative agreements. Brownfields sites tend to have greater location efficiency than alternative development scenarios. Results of five pilot studies show a 32 to 57 percent reduction in vehicle miles travelled when development occurred at a brownfield site rather than a green field. Fewer vehicle miles traveled mean a reduction in pollution emissions including greenhouse gases. These same site comparisons show an estimated 47 to 62 percent reduction of storm water runoff for brownfield site development. Another EPA study found that residential property values increased by 5.1–12.8% percent once a nearby brownfield was assessed or cleaned up. The study determined that brownfield clean up can increase overall property values within a one-mile radius by $0.5 to $1.5 million. Initial anecdotal surveys indicate a reduction in crime in recently revitalized brownfield areas. Opportunity to expand the assessment program and leverage funds and jobs has increased. Policy analysis allows the use of site assessment dollars for environmental assessments in conjunction with efforts to promote area-wide planning around brownfield sites. The use of funds for these purposes is particularly important in economically distressed areas. In certain instances where assessments reveal immediate threats to the environment or human health, EPA could implement a more programmatic use of removal funds.

Paul Nathanail

Invited Speaker

An Overview of the History, Accomplishments, and On-going Initiatives of the Sustainable Remediation Forum (SURF)

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Abstract

Over the last decade, many sectors of industrialized society have been rethinking behavior and re-engineering practices to reduce consumption of energy and natural resources. The Sustainable Remediation Forum (SURF) promotes the use of sustainable practices during the investigation, construction, redevelopment, and monitoring of remediation sites, with the objective of balancing economic viability, conservation of natural resources and biodiversity, and the enhancement of the quality of life in surrounding communities. Since its founding in 2006, SURF has brought together the best and the brightest in the remediation field, and has led the evolution of sustainable remediation (SR) from conceptual discussions to standard operating procedure. The mission of SURF is to maximize the overall environmental, societal, and economic benefits of the site cleanup process. SURF was the first to consolidate broad-based institutional knowledge into an exploration of SR drivers, practices, objectives, and case studies. SURF's groundbreaking White Paper was published in a special edition of the Summer 2009 Remediation Journal. SURF has continued to expand on the topics explored in the White Paper, including publications on its SR framework, metrics compendium, life cycle assessment guidance, and a call to improve the integration of land remediation and reuse. SURF's current efforts focus on groundwater conservation and reuse, international collaboration on SR, and ways to capture and evaluate the socio-economic benefits of contaminated site cleanup. SURF's ongoing objective is to provide a forum for representatives of government, industry, consultancy, and academia to parse the means and ends of incorporating societal and economic considerations into environmental cleanup projects. SURF collaborates, educates, advances, and develops consensus on the application of sustainability concepts throughout the lifecycle of remediation projects, from site investigation to closure, and eventually reuse of the property. SURF members accomplish these objectives through volunteer working groups.

Keywords: SURF, sustainable remediation, Life-Cycle Assessment, Groundwater Conservation and Reuse

Mine Remediation Training and Employment In Canada's North

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Abstract

Canada's North is plagued with a number of Contaminated Mine Sites from open discharges to freshwater lakes, streams, and rivers. Together with this, one will find aboriginals who are having great difficulty finding work because of the nature of the work available and the difficulty of finding skills available. A number of organizations including various levels of government, and a number of private sector engineering firms were brought together by the Environmental Careers Organization Canada (ECO) under the direction of Grant Trump, CEO of ECO to determine a solution.

Keywords: Climate Change, ECO, Contaminated Sites, Mining Remediation, aboriginal employment

Beneficial Use of Coal Combustion Residuals for the Sustainable Land Remediation in Korea

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Abstract

Lands nearby abandoned mines are exposed to various types of mine hazards in Korea. Soil is susceptible to heavy metal contamination with erosion of mine wastes and use of mine water as an irrigation source. Alternative option for soil remediation is critically needed in the abandoned mine area being located in the steep valley. Coal combustion residuals (CCR) from power plants are alkaline resources that have potential to be beneficially used for land remediation. Objective of this research was to assess the possibility of CCRs to remediate the metal contaminated lands. The segment plots were constructed in the coal waste heap that has 56% of slope and size was 30x3m (LxW). Varied ratio (20 and 40%) of CCR was mixed or layered with mine waste. pH and heavy metal concentration in soil, runoff and leachate were periodically monitored. After treating the plot with CCR, the surface was hydro-seeded to cover the surface with native grass species. Growth vigor and surface cover of the grasses were assessed. CCRs neutralized the soil, runoff and leachate from pH 4 to 7. Concentrations of metal such as As, Al, and Fe were significantly reduced in soil and water samples with CCR application. As mixing ratio of coal ash with mine waste is increased, more growth of plants was observed. Results suggest that CCR can be utilized to remediate mine waste due to high efficiency in increasing pH, stabilizing the heavy metals and enhancing the vegetative covers in the mine-impacted land. Reuse of CCR as a remedial resource, being coupled with adopting environmental parameters specific to the land, can be a sustainable method for land remediation.

Keywords: Mine waste, Coal combustion residuals, Heavy metals, Neutralization, Vegetation

Containment and Bioreactor, Wetlands, or Ion Exchange Resin Ex-Situ Treatment to Facilitate In-Situ Remediation

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Abstract

It is often impractical to remove a sufficient amount of contaminant mass to achieve drinking water standards at properties containing either a large amount of contaminant mass and/or over a large areal extent. Similarly, decades may be required before the risks to humans or the environment are fully removed. During this period, isolation of the chemicals from the potential receptors, containment, may be the only viable alternative. The methods of implementing containment can vary widely, and some can enhance the implementation of other remedies that accelerate contaminant mass removal.

This paper evaluates two sites in MWH's portfolio where containment was used in traditional applications but where the composition of the extracted water required creative solutions to provide cost-effective long-term treatment. One site uses a combination of a high density polyethylene (HDPE) barrier, extraction trenches, and activated sludge water treatment. Dewatering afforded an opportunity to remove containment mass by soil vapor extraction (SVE). The other site uses a soil and bentonite wall, wells, and will use a membrane bioreactor (MBR) to treat a spectrum of chemicals.

Four sites are also discussed where containment was or is being used to safely implement in-situ treatment. Three of the sites share a common contaminant, hexavalent chromium; common approach, in-situ chemical reduction (ISCR) using calcium polysulfide (CaSx); and vertical well extraction with recirculation; however, the method of ex-situ treatment and in-situ delivery vary, including direct chemical reduction or ion exchange (IX) and infiltration basins, trenches, or vertical well injection. The fourth site is a former petroleum refinery where interceptor trenches protect a sensitive receptors and an engineered wetland provides low-cost long-term water treatment. A component of the remedy is phytoremediation to accelerate source area treatment.

Lesson's learned include: when to use strong base anion (SBA) versus weak base anion (WBA) exchange resin; how wetlands can provide cost-effective long-term treatment when space is available; how humic substances can interfere with analysis and methods to remove them; how groundwater extraction and reinjection can be used to enhance in-situ treatment; and how the composition of total organic carbon (TOC) can vary and its impact on treatment equipment.

Keywords: containment, high density polyethylene (HDPE), bentonite, in-situ chemical reduction (ISCR), calcium polysulfide (CaSx), ion exchange (IX), advance oxidation process (AOP), activated sludge, membrane bioreactor (MBR), trench, engineered wetlands, phytoremediation.

Challenges in implementing groundwater remedial technologies in Asia with case studies from Japan: Permeable Reactor Barrier (PRB) and In-Situ Thermal Remediation (ISTR)

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Abstract

Clients based in environmentally more mature jurisdictions such as North America, Europe, and Australia often face challenges in properly characterizing industrial sites and implementing innovative and technically robust soil and groundwater remedial technologies in Asia. The reasons are many but broadly include lack of experienced contractors, site characterization tools, access to laboratories, differences in technical specifications / codes and permitting, language barriers, differences in business styles and contracting, remoteness / logistics, climate, import restrictions, political environment, differences in and/or lack of environmental regulations and standards, absence of risk assessment methodologies, and lack of experienced regulatory officials.

These challenges can be overcome, however, through careful planning, iterative high resolution site characterization using imported tools, scientifically robust feasibility studies, use of modeling (probabilistic, fate and transport, thermal), detailed design which accounts for a local delivery, and early engagement with regulatory officials and other stakeholders.

Environmental Resources Management has been remediating contaminated land sites in Asia for over 20 years. This paper will present delivery on two recent projects in Japan where we implemented the installation of a 300m long Permeable Reactive Barrier (PRB) wall and construction of a steam enhanced In-Situ Thermal Remediation (ISTR) system, the challenges we faced, and how we overcame such barriers in delivering these innovative technologies for our clients.

Sustainable Remediation: Incorporating sustainability into risk-based soil and groundwater management projects

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Abstract

In the past decade management of historically contaminated land has largely been based on prevention of unacceptable risks to human health and the environment, to ensure a site is 'fit for use'. More recently interest has been shown in including sustainability as a decision-making criterion. Sustainability concerns include the environmental, social and economic consequences of risk management activities themselves, and also the opportunities for wider benefit beyond achievement of risk-reduction goals alone. In the UK this interest has led to the formation of a multi-stakeholder initiative, the UK Sustainable Remediation Forum (SuRF-UK). This paper presents a framework for assessing 'sustainable remediation'; describes how it links with the relevant regulatory guidance; reviews the factors considered in sustainability; and the appraisal tools that have been applied to evaluate the wider benefits and impacts of land remediation. The paper also describes how the framework relates to recent international developments including emerging European Union legislation and policy. A large part of this debate has taken place in the "grey" literature which we review. It is proposed that a practical approach to integrating sustainability within risk-based contaminated land management offers the possibility of a substantial step forward for the remediation industry, and a new opportunity for international consensus.

Keywords: sustainable remediation, risk assessment, risk-management, soil, groundwater

Environmental Forensics and Remedial Site Investigations

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Abstract

Environmental forensics is the investigation that is focused on identifying potential contaminant source(s) at a contaminated site using legally defensible methodologies. Contaminant source issues arise from various contexts (e.g., on-site vs. offsite and historical vs. recent), but at their core they revolve around the identification of primary sources (i.e., points or areas of original releases) and secondary sources (i.e., derived from primary sources). At sits where there are disputes on the contaminant sources, remedial costs are often allocated among potential responsible parties (PRPs). Cost allocation is complex and depends on many other factors such as volume of contaminants, time of operation involving the contaminants, risk associated with the contaminants and contribution of contaminant sources requiring remediation (Marryott, et al., 2000; Murphy, 2000; USEPA, 2000, Owete, 2007). However, identification of primary and secondary sources is one of the most critical elements in the process as it is the foundation for all other cost related assessments.

In environmental remedial site investigations, the ultimate objective is to determine the nature and extent of contamination (i.e., currently impacted areas). The contaminant source issues from a legal standpoint are of as much interest to site remedial scientists and engineers because contaminant sources need to be well understood in order to develop a sound conceptual site model (CSM). In a CSM, contaminant sources and release migration pathways are among the two most critical components (Lu, 2015). In a site where contaminant sources are known and geology and hydrogeology (i.e., release migration pathways) are well understood, delineation of the currently impacted areas can be done with high certainty. However, in a site where knowledge of site release history is incomplete and geology and hydrogeology is complex, delineation of the currently impacted areas is extremely challenging. In this case, identification and characterization of contaminant sources will provide critical information in predicting release migration pathways and ultimately understanding and/or delineating the currently impacted areas.

A variety of environmental forensic techniques have been developed over a long history of litigation (Morrison, 2000; Sullivan et al., 2000; Morrison and Murphy, 2006; Wang et al., 2007; Murphy and Morrison, 2015). Validity of most of these techniques is established as they are not only published in peer reviewed scientific journals, but also have been critically evaluated and vigorously scrutinized during the litigation process. Environmental forensic techniques are contaminant specific; but can be generalized into a number of categories including aerial photography, chemical commercial availability and use, fingerprinting, diagnostic compounds and ratio analysis, stable isotope analysis, modeling and statistics. This paper provides an overview of commonly used forensic techniques and presents two case studies to demonstrate application of environmental forensic techniques to source characterization in remedial site investigation.

The first case study demonstrates importance of differentiating current from historical releases using a tiered analytical approach for petroleum hydrocarbon fingerprints. At a petroleum terminal, an aboveground diesel storage tank was suspected of leaking following an earthquake, as evident from a two-to three-foot wide area of hydrocarbon stained surface soil along the perimeter of the tank. A forensic investigation was conducted to determine whether soil adjacent to and beneath the tank was impacted from the diesel fuel that may have leaked from the tank.

Twenty-four soil samples were initially analyzed for C7-C27 carbon chain using EPA Method SW8015B. Following review of the analytical results, four out of the 24 soil samples, one diesel fuel sample from the tank and one light non-aqueous phase liquid (LNAPL) sample from a nearby monitoring well were selected for gas chromatography/mass spectrometry (GC/MS) using total ion monitoring (TIM) data acquisition mode. Based on comparison of fingerprints between the hydrocarbons from soil samples, the diesel fuel sample from the tank and the LNAPL sample from the well, the hydrocarbons encountered at the deeper soil beneath the tank were determined to be not

sourced from the diesel fuel from the tank; however, uncertainty remained on the source relationship between the diesel in the tank, hydrocarbons in the shallow soils beneath the tank and soils along the perimeter of the tank.

Additional laboratory analyses were conducted using GC/MS selected ion monitoring (SIM) data acquisition mode for polynuclear aromatic hydrocarbons (PAHs) and sesquiterpane biomarkers. Based on detailed forensic analysis, it was concluded that the hydrocarbons in the shallow soils were not related to the diesel fuel in the tank. As the historical impact is being addressed by an on-going remediation program overseen by a regulatory agency, differentiation of historical from current releases avoided unnecessary further investigation.

The second case study is to demonstrate on-site vs. off-site sources. A former manufacturing facility had historic release(s) of tetrachloroethene (PCE) and trichloroethene (TCE) to the subsurface with both on-site and off-site groundwater impacts. Site remediation employed source area removal and groundwater extraction and treatment at the downgradient property boundary. The responsibilities for off-site subsurface impacts (i.e., groundwater, soil vapor and potential indoor vapor intrusion) were disputed by adjacent downgradient property owners who also utilized PCE and TCE for multiple industrial and commercial activities. From a remediation perspective, understanding of potential off-site sources is also critical in development of a strategy for the expeditious clean-up.

To evaluate PCE and TCE source relationship between on-site and off-site, CSIA was included as a part of the investigation process. CSIA has been used extensively for biodegradation evaluation in remedial investigation. It is also applicable for source differentiation because the isotopic composition of manufactured organic compounds depends on the isotope ratio of the source materials and on isotope fractionation during production of the compounds (U.S. EPA, 2008). At sites where multiple potential sources of the same ground water contaminants are present, CSIA is extremely valuable in resolution of source issues. The objectives of the study were to determine 1) isotopic signature of the PCE and TCE in groundwater from the former manufacturing facility and on the adjacent properties; 2) if an off-site source(s) was contributing to the off-site PCE and TCE groundwater plume; 3) if soil gas impacts on adjacent properties were from on-site sources or from off-site activities.

Groundwater samples were collected from 13 on- and off-site monitoring wells and soil gas samples from three locations at five discreet depth intervals per location. These samples were analyzed for two dimensional (2-D) CSIA for PCE and 3-D CSIA for TCE. The analysis of groundwater CSIA data demonstrated that there appear to be one TCE source and several potential PCE sources off site. Soil gas results for PCE correlate with off-site carbon and chlorine isotope signature suggesting three potential off-site sources for PCE. Soil gas results for TCE indicate two off-site TCE sources that are not related to the on-site releases.

In a summary, the study determined that the off-site groundwater plume of PCE, TCE and degradation products is a comingled plume that has resulted from the known on-site releases and received contributions from the off-site sources. With CSIA findings, in conjunction with other investigative data, the local state regulatory body was convinced with the conclusions with regard to multiple off-site contributions to the groundwater plume and no on-site contribution to the offsite soil vapors. Consequently, the focus of remedial investigation has been shifted from onsite to offsite to identify offsite contaminant sources that contribute to groundwater PCE and TCE plume and indoor air pollution.

Key words: Environmental forensics, contaminant sources, conceptual site models, environmental forensic techniques, chemical fingerprinting, and compound specific isotope analysis (CSIA)

Current Approach Used in Canada for Managing Contaminated Sites under the Federal Contaminated Sites Action Plan (FCSAP) – Case Study Example.

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Abstract

In 1989, the Canadian Council of Ministers of the Environment (CCME) and the Government of Canada created the National Contaminated Sites Remediation Program (NCSRP) and under this program, a method for classifying contaminated sites according to their current or potential adverse impacts on human health and the environment was developed. In 1990, Environment Canada committed to assisting custodians with identifying, assessing, and remediating high-risk contaminated sites within their jurisdictions. As a result, 325 federal sites were investigated. The creation of the Contaminated Sites Management Working Group (CSMWG) in 1995 was a major step forward in addressing federal contaminated sites. The 2002 Report of the Commissioner of the Environment and Sustainable Development indicated a need to produce an action plan to deal with high-risk sites in a timely manner. Recognizing the need for a coordinated approach, the government established the Federal Contaminated Sites Action Plan (FCSAP) program in 2005. Under the FCSAP program, assessment activities were conducted at over 9,400 sites and remediation activities at roughly 1,400 sites across Canada. The focus of this manuscript is to present the current approaches used in Canada for managing contaminated sites under the FCSAP program as well as to present a study case example.

Keywords: FCSAP, ERA, CCME, ecological, risk management.

Recent progress in bioremediation study of POPs-contaminated soil

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Abstract

Clean-up technology for contaminated soil and water with persistent organic pollutants (POPs) and other pesticides is required. A novel aerobic pentachloronitrobenzene (PCNB)-degrading bacterium, *Nocardioides* sp. strain PD653, was isolated from an enrichment culture in an original soil-charcoal perfusion system. Strain PD653 also degraded hexachlorobenzene (HCB) and β-HCH to CO_2 with dissociation of chloride ions under aerobic conditions. It is the first aerobic bacteria capable of mineralizing HCB. Besides, hexachlorocyclohexane (HCHs)-degrading bacterium (*Sphingomonas* sp. strain TSK-1) and dieldrin-degrading bacterium (*Pseudonocardia* sp. strain KSF27) were isolated form upland soil where γ-HCH or endosulfan had been annually applied, respectively using this system. Strain TSK-1 degraded aerobically α, β, γ, and δ-HCH. Six chloride ions per molecule occurred with completely degradation of α, γ and δ-HCH after 4 and 10 days incubation. For β-HCH, however, two chloride ions per molecule were released with 90% of degradation after 10 days incubation. To apply mixture of these bacteria (PD653 and TSK-1) to contaminated soil, we developed a special charcoal (CC 150) enriched with 2 degrading-bacteria. After mixing 5% this charcoal with historically HCHs-contaminated soil (71.5 mg/kg), approximately 76 % of γ-, 67% of α-, 35% of δ- and 19% of β-HCH were degraded after 2 weeks incubation. Strain KSF27 degraded dieldrin from 14.06 μM to 2.01 μM over a 10-day incubation. As a major metabolite, aldrindicarboxylic acid was detected. Moreover, an aerobic dieldrin-degrading fungus, *Mucor racemosus* strain DDF, was isolated from soil annually treated with endosulfan. Strain DDF degraded dieldrin to 1.01 μM from 14.3 μM during a 10-day incubation. As a dead end product, aldrin-*trans*-diol *exo*- and *endo*-phosphates were detected via aldrin-*trans*-diol. Phosphorylation of aldrin-*trans*-diol is the first reported example of phosphate conjugation in microorganisms. When strain DDF with wheat bran was treated into the historically contaminated soil, dieldrin degraded 47% after 3 weeks incubation.

Keywords: soil-charcoal perfusion method, degrading microbes, HCB, HCHs, dieldrin, metabolites, UPLC/MS, GC-MS, historically contaminated soil

Microbial Biodegradation of Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)

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Abstract

Hexahydro-1,3,5-trinitro-1,3,5,-triazine (RDX) is a cyclic nitramine explosive that frequently contaminate soils and groundwater near army ammunition plants and military sites. RDX is also a possible human carcinogen. Bioremediation has been considered as viable option for remediating RDX-contaminated soil and groundwater. In this review, current knowledge of microbial biodegradation of RDX with respect to degradation pathways, degradative genes and isolates, as well as RDX-degrading microbial community in soil and groundwater was discussed.

Keywords: RDX, microbial biodegradation, explosive, bioremediation,

Green and Sustainable Remediation: A Review and an Outlook

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Abstract

Green and sustainable remediation (GSR) creates an added benefit to legally required or otherwise necessary remediation of contaminated land to protect human health and the environment. Added benefit increases the value beyond monetary aspects of the remediation project by including additional stakeholders besides the Site owner, environmental consultant and the regulatory entity and considering not only environmental, but also social and economic aspects of the remediation program. While GSR is still an emerging field in the contaminated land management industry, various groups across the globe have dedicated their efforts to advance the understanding of sustainability assessment drivers, improve and develop GSR assessment tools to quantify impacts of various parameters, create a philosophy around the concept of GSR, and develop guidelines how to best implement "sustainability" and maximize the net benefit in remediation projects. In various countries GSR teams developed frameworks and road maps to green & sustainable remediation providing a supporting structure for stakeholders to evaluate on a site-specific basis the aspects of their specific project. The release of frameworks for sustainable remediation within the US, UK and Europe occurred between 2010 and 2012. While those framework documents were crafted based on the same set of ideas and in the same spirit, they are not the same. A single, unified and international sustainable remediation framework would allow practitioners a process-driven guideline that could be implemented in various project settings around the globe. It would allow the flexibility to adjust as needed based on project location, size and complexity of the project, regulatory context, and project-specific stakeholders with their individual needs, and still deliver comparable results for different projects completed under different circumstances "somewhere else" in the world. An internationally accepted certification for sustainable remediation practitioners would lend additional credibility and expertise to the objectivity of the process-driven decision-based outcome of each remedial sustainability assessment.

Keywords: Green, sustainable, remediation, GSR, benefit, economic, environment, assessment, tools

Invited Speaker

Remediation of Heavy Metal(loid)s Contaminated Soils – to Mobilize or to Immobilize?

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Abstract

Unlike organic contaminants, metal(loid)s do not undergo microbial or chemical degradation and persist for a long time after their introduction. Bioavailability of metal(loid)s plays a vital role in the reme-diation of contaminated soils. In this review, the remediation of heavy metal(loid) contaminated soils through manipulating their bioavailability using a range of soil amendments will be presented. Mobilizing amendments such as chelating and desorbing agents increase the bioavailability and mobility of metal(loid)s. Immobilizing amendments such of precipitating agents and sorbent materials decrease the bioavailabilty and mobility of metal(loid)s. One of the major limitations of mobilizing technique is susceptibility to leaching of the mobilized heavy metal(loid)s in the absence of active plant uptake. Similarly, in the case of the immobilization technique the long-term stability of the immobilized heavy metal(loid)s needs to be monitored.

Keywords: bioavailability, heavy metals, mobility, soil amendments

Low-Threat Underground Storage Tank Case Closure Policy in California

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Abstract

The State Water Resources Control Board and Regional Water Quality Control Boards have been authorized under California Health and Safety Code and California Code of Regulations to administer the petroleum Underground Storage Tank (UST) Cleanup Program since 1984. A UST Cleanup Fund was established in 1989 to support UST case investigations and cleanups. In order to utilize the fund effectively, many UST regulations and policies were developed to ensure consistency and efficiency, including a low-threat underground storage tank case closure policy effective August 17, 2012. This policy, that set up general and media specific case closure criteria using technical justification and screening levels will be described. Implementation procedures of the policy and regulatory tools will also be discussed, including the relevant California Water Code sections and General Waste Discharge Requirements for In-situ Groundwater Remediation and Groundwater Re-injection adopted September 11, 2014.

Keywords: Underground Storage Tank (UST), soil and groundwater contamination, UST closure, regulations and policy

Assessment of ecological risks in coastal sediments: An Australian oil refinery case study

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Abstract

In response to a regulatory requirement for clean-up of an oil refinery site, an ecological risk assessment was conducted to determine whether significant impacts on the intertidal and near shore marine ecology were likely to be occurring. A weight of evidence approach was adopted, employing multiple lines of evidence over a number of years to reach a conclusion on the acceptability of risk. The study included sediment and porewater chemical analysis and ecotoxicity testing, an investigation of benthic macroinvertebrate populations and chemical analysis of tissue samples from sessile organisms. The study design was agreed with the regulator and results communicated over a series of reports and briefing sessions, and was peer reviewed by CSIRO. The work was also subject to third party audit, which is a regulatory requirement of the Australian contaminated land system. The results indicated localized significant toxicity along the foreshore in porewater and sediments affected by LNAPL, but no significant differences in benthic assemblages were observed between impacted and non-impacted locations. Both toxicity and chemical concentrations declined rapidly away from the foreshore, with degradation of petroleum hydrocarbons apparently being driven by wave action in the intertidal zone. No accumulation of hydrocarbons in mussel tissue was detected. In the context of a very well characterized site, and with migration of impacts from the Refinery site under control, the study concluded that remedial action to protect ecosystems was not required, because the benefits to the ecology that could be achieved by removal of impacts would be likely to be insignificant and restricted to a very small area of foreshore. The potential damaging effects of mobilizing contamination over a wider area as a result of a remedial excavation were also considered in reaching this decision. The conclusions of the study were accepted by the regulator.

Keywords: quantitative risk assessment, ecological risk, marine sediments, oil industry, risk based decision making

The role of biochar, natural iron oxides and nanomaterials as soil amendments for immobilizing metals in shooting range soil

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Abstract

Heavy metal pollution of soils is a matter of concern worldwide. High concentration of toxic metals in military shooting range soils poses a significant environmental concern due to the potential release of metals such as Pb, Cu, and Sb, and hence requires remediation. The current study examined the effectiveness of buffalo weed (*Ambrosia trifida* L.) biomass and its biochar produced at pyrolytic temperatures of 300 and 700 ℃, natural iron oxides (NRE), gibbsite, and silver nanoparticles on metal immobilization together with soil quality. Contaminated shooting range soils by heavy metals were treated with these amendments and incubated for a year. After incubation, destructive (e.g. chemical extractions), and non-destructive (e.g. molecular spectroscopy) methods were used to investigate the immobilization efficacy of each amendment on Pb, Cu, and Sb, and possible mechanisms. Biochar induced larger increase of cation exchange capacity (CEC) in the soil than the other amendments. The best immobilization was for biochar produced at 300 ℃, showing the maximum decreases of bioavailability by 94% Pb and 70% Cu. We attributed this to the greater abundance of functional groups in the biochar. Biochar originated P in the soil, and increased soil pH and CEC. However, no amendment was effective on Sb immobilization. As a non-destructive approach, scanning electron microscopic elemental dot mapping and X-ray absorption fine structure spectroscopic (EXAFS) studies revealed associations of Pb with P (i.e. the formation of stable chloropyromorphite [$Pb_5(PO_4)_3Cl$]) in the biomass- or biochar-amended soils.

Keywords: black carbon, charcoal, metal availability, nanoparticle, slow pyrolysis, synchrotron

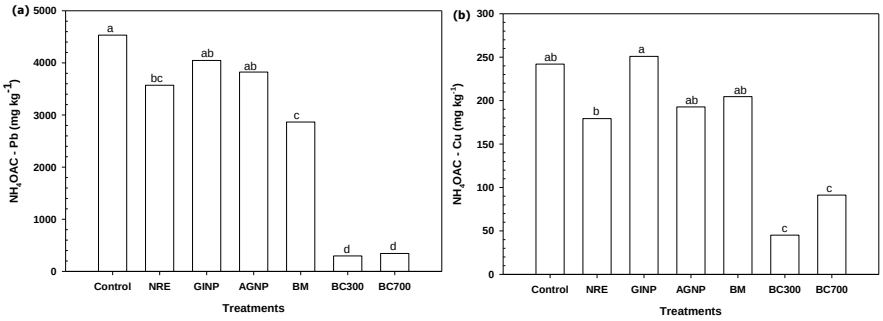

Figure 1. NH_4OAC- extractable (a) Pb and (b) Cu in shooting range soil treated with natural iron oxide (NRE), gibbsite nanoparticles (GINP), silver nano particles (AGNP), biomass (BM), and biochars pyrolyzed at 300 ℃ (BC300), and at 700 ℃ (BC700). The same letters above each bar indicate no difference at a 0.05 significance level.

Oral Session

Sustainable Remediation

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Brownfields Screening, Redevelopment Planning and Prioritization Process Promoting in Taiwan

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Extended abstracts

Land resources are vital to Taiwan, which is an island with high population density. Under the announcement of Soil and Groundwater Remediation Act, Soil and Groundwater Pollution Remediation Fund Management Board was funded and plays an important role in the investigation of contaminated sites in Taiwan. With the number and area of brownfields continued to increase in Taiwan, there is a need for the Government to make a redevelopment priority list of brownfields under limited funds and information, and to establish appropriate reuse and redevelopment planning processes for these contaminated sites.

We describe a framework of assessment methods and models that analyses the redevelopment priority of contaminated sites after screening stages, with the aim to set up the priority classification of them. An assessment framework was then constructed to support this idea by assessing the public benefits and economics benefits results from the reuse and redevelopment processes.

In our framework, there are two dimensions which represent environmental and social aspect and economics aspect, respectively. After sort up the sequence on each dimension, four quadrants were further constructed in order to analyze the priority. This framework integrates population density, land values, traffic hub, pollutant compound, pollutant concentrations, pollutant transport pathways, land usage sites, site areas, and water conductivity into consideration.

Case studies results show that there are 10% high priority sites (both consist of environmental and social benefits and economics benefits), 17% environmental and social priority sites, 30% economics priority sites and 43% non-priority sites. Furthermore, three contaminated sites were used to evaluate the economics benefits after their own redevelopment processes in order to make a verification of this framework. The results indicates that all three sites were classified as economics priority sites.

Keywords: Brownfields, Contaminated Sites, Redevelopment, Planning, Screening, Prioritization

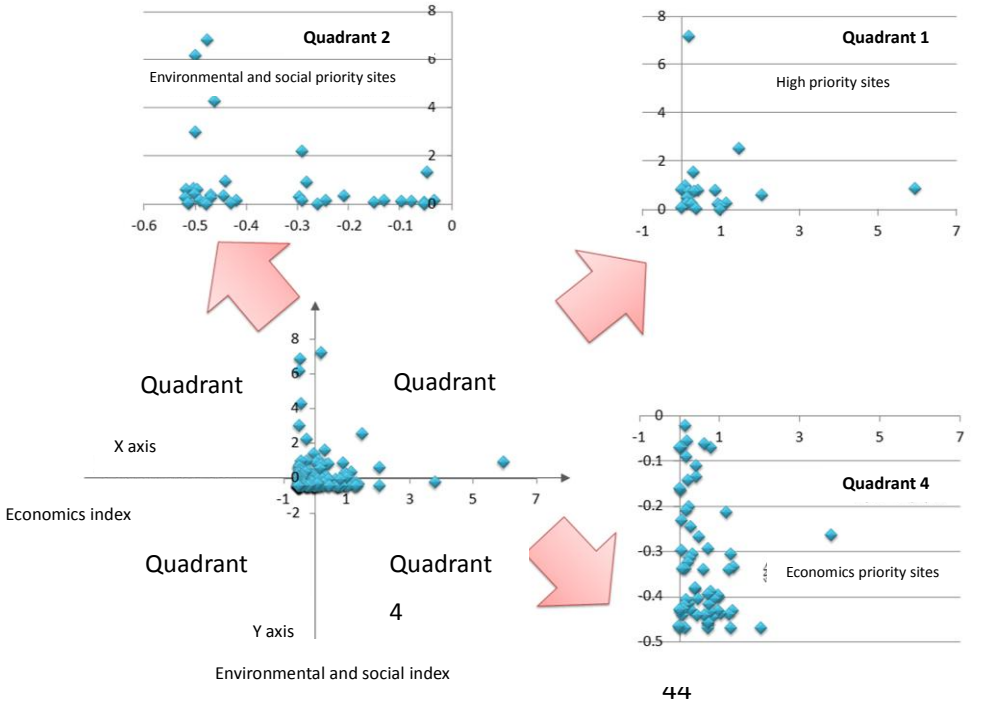

Figure 1: Redevelopment priority classification framework of brownfields in Taiwan

Vapour (TCE) intrusion and the relocation of people from their homes – the cause, the relocation, the science, the outrage

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Extended abstract

In Australia, and other parts of the industrialised world, manufacturing and industry are often located close to residential properties. Clovelly Park (a southern suburb of Adelaide, South Australia) has a history of motor vehicle manufacturing, dating back to the 1950s (Chrysler). In the 1960s, widespread residential development extended to Clovelly Park - replacing the remaining farms and orchards.

In 2008, as a part of the due diligence process for the sale of its Clovelly Park site, Mitsubishi Motors Australia Ltd (Mitsubishi) undertook groundwater testing at the southern boundary of its site. This testing indicated the presence of elevated concentrations of trichloroethene (TCE) in the groundwater. Considerable testing followed and soil vapour was found to be entering buildings and homes, south of the site.

In April 2009, public housing residents from 16 apartments in a block of flats and three single-storey units were relocated due to elevated indoor concentrations of TCE. The block of flats and one unit have since been demolished.

Mitsubishi and its neighbor, Monroe/Tenneco (an automotive parts manufacturer), commissioned over sixty assessment programs. All of the properties tested (accept those above) were reported as having acceptable concentrations of TCE in indoor air.

In late 2013 Monroe undertook (baseline) testing inside one vacant house in preparation for a vapour intrusion mitigation trial. The indoor air concentrations for TCE in this house had previously been reported to be acceptable and below 2µg/m^3 (WHO). However a result for a bedroom, that had not previously been tested, was reported as 84µg/m^3. A second round of testing verified this result and it was presented to the EPA in May 2014 (as a draft Vapour Intrusion Risk Assessment (VIRA) report).

In reviewing the VIRA report, public health officials considered that there was sufficient evidence to indicate that a public health risk exists and that there was a need, as precautionary action, to relocate (over 6 months) the people living in this area (31 properties).

An extraordinary meeting of the State Emergency Management Committee took place on 25 June 2014 where it was recommended that a cross government Taskforce be established to coordinate the government's response to the situation outlined above.

On 2 July 2014, the matter was raised in State Parliament by the Opposition. This occurred before the EPA, SA Health and Housing SA were able to speak with affected residents. The media immediately responded by converging on Clovelly Park. The manner in which this news was delivered remained the focus of considerable public and media attention in the coming days and weeks. The residents were very distressed by the manner in which the news was delivered to them. Considerable anger and outrage followed.

The Parliament of South Australia established a committee to "inquire into and report on the Environment Protection Authority's management of contamination at Clovelly Park and Mitchell Park, with particular reference to assessment and management of risks to public health by the Authority and related agencies".

Based on the May 2014 VIRA report, the EPA determined that the contamination might be more

widespread than originally thought. The EPA sought government funding ($1.1M AUD / $30M NTD) to:

- determine the nature and extent of the groundwater, soil and soil vapour contamination within an EPA Assessment Area (approximately 1400 properties),
- determine the sources presenting the soil vapour plume(s),
- prepare a human health risk assessment and a vapour intrusion risk assessment within the EPA Assessment Area,
- prepare a report for the residents in the EPA Assessment Area; and
- determine the geometry of a groundwater prohibition area including a buffer area within the EPA Assessment Area.

This work was commissioned in mid-August. The results will be reported in early December 2014. It is the largest project of its type ever undertaken in the southern hemisphere and has been subject to considerable national and international attention.
On 18 August 2014, a Clovelly Park Mitchell Park Project Management Team was established to lead and co-ordinate the whole of State Government response to the matter. The team is working closely with the EPA and SA Health as well as other Government Agencies and private sector organisations involved in the project.

Considerable work has occurred with the community in relation to understanding what is known, what is not known and detailing the assessment program. Regular update meetings are held with the community. A website for the project has been established: http://cpmpproject.sa.gov.au

Advances in Surfactant Enhanced Aquifer Remediation: Lessons Learned and New Trend

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Extended abstract

We will present the significant results from several field-scale projects for clean-up of contaminated soils and ground waters applying surfactant-enhanced aquifer remediation (SEAR). In brief, researchers at University of Oklahoma (U.S.A.) and Surbec Environmental (Norman, Oklahoma) completed 40 plus site remediation projects impacted by light non-aqueous phase liquids (LNAPLs) over the course of last decade. The goals for these environmental remediation efforts were mainly for free product removal (basically greater than 90 to 95% product removed) for a variety of fuels, soils, and hydrogeological conditions. The designing criteria and engineering approach of the surfactant flushing involve injecting one to two pore volumes (PV) of special surfactant blend (< 1 wt% of total concentration) based on laboratory treatability studies for the site-specific contaminants, ground waters and soils. Once injected and reached the oil and water interface, it would create the middle-phase microemulsions with ultra-low interfacial tensions (IFTs), i.e., enabling to successfully mobilize the entrapped oils from the subsurface. Our recent endeavor has been focused on developing next generation surfactant system which can offer improved remediation performances with exceptional technical and cost benefits (e.g., lower surfactant dosage, reducing salt requirements, and fast residual surfactant degradation in subsurface) as compared to the existing patented surfactant formulations and conventional practices. In this talk, we will present the designing approach of our ongoing reformulation efforts for next generation SEAR, and in particular, the results of laboratory screening tests for these newly developed surfactant formulations, including several unique binary and ternary surfactant mixtures potentially exhibiting faster biodegradation rates under different aquifer conditions. Based on the encouraging results of these laboratory screening tests, we expect to conduct the field pilot test in next six to twelve months for further verification and collecting the designing data required for future full-scale implementation using these new generation surfactant system for environmental site remediation.

Green and Sustainable Remediation Development in Taiwan

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Extended abstract

In 1980s, various types of soil and groundwater contaminated sites were found. In order to manage and supervise growing numbers of site investigation and cleanup activities of subsurface environment, the Soil and Groundwater Remediation Act was enacted in 2000. Since then, contaminated site investigation and remediation have developed a comprehensive management system. However, cleaning up contamination and preparing impacted land for reuse requires substantial energy, water, and other natural resources. The environmental regulator and remediation industry have recognized the potential high environmental footprints and social and economic impacts during the course of cleanup. Consequently, different issues have been rethought to incorporate sustainable concepts into the remedial process. Therefore, the overall remediation practices can maximize the overall environmental, societal, and economic benefits, which is the central spirit of green and sustainable remediation (GSR).

In 2012, Taiwan Environmental Protection Administration (TEPA) initiated a framework and executive flowchart for promoting GSR and cooperated with SuRF-Taiwan to organize the first Sustainable Remediation Forum. For the past two years, TEPA and SuRF-Taiwan have jointly worked on GSR development in Taiwan. This paper describes the development of the GSR framework, executive flowchart and summarizes the methodologies used in GSR assessment. Under the GSR framework, TEPA has developed various tools to encourage site managers to adopt GSR during the site cleanup process, including a remedy selection decision MCA tool, an environmental footprint analysis tool, a BMPs screening list, a social questionnaire sample and an economic impact analysis tool. In 2014, three demonstration sites implemented sustainable principles throughout the cleanup activities. Results of the GSR assessment will also be presented in this paper. Through environmental footprint assessment and human health risk assessment, remedy alternatives comparison and subsequent BMPs planning were conducted for the demonstration sites.

Keywords : Green and Sustainable Remediation, Best Management Practices, Environmental Footprint assessment

Management of groundwater quality in Taiwan

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Extended abstract

Groundwater resource is critical for domestic, agricultural, industrial water demands in Taiwan. Groundwater quality is gradually concerned as an environmental and economic issue in the last decades. However, long-term groundwater contaminations usually threaten the safety and the right of groundwater usage. According to last 10 years monitoring data by Taiwan EPA and WRA, the major problems of groundwater quality include arsenic (As) contamination of southwestern area, nitrate pollution of central mountain area, salinization of coastal area. The groundwater contaminant potential map (Figure 1) is established by Taiwan EPA. The most important task of these groundwater quality issues is the management of contaminated groundwater in potential regions. The occurrence of groundwater As in Taiwan is proved that the reducing dissolution of As-enriched iron/manganese hydroxides is the plausible mechanism. The health risk of geogenic As issue can be reduced by the selection of proper depths or aquifers and dilution with surface water, rather biochemical remediation. For nitrate pollution, over-fertilization and rapid infiltration of mountain area are the main anthropogenic and hydrogeological causes, respectively. Optimizations of fertilization, irrigation, drainage of crop are hence the effective approaches for decreasing the nitrate concentrations. Moreover, extended pumping of coastal areas for agricultural and aquacultural demands has led to land subsidence and seawater intrusion. The groundwater salinization can be improved by reducing groundwater abstraction and increasing surface water recharge. The early warning monitoring network have to be developed to understand the spatial-temporal variation of coastal seawater and to provide strategic decision of groundwater usage.

Keywords: Groundwater, management, arsenic (As), nitrate, salinization

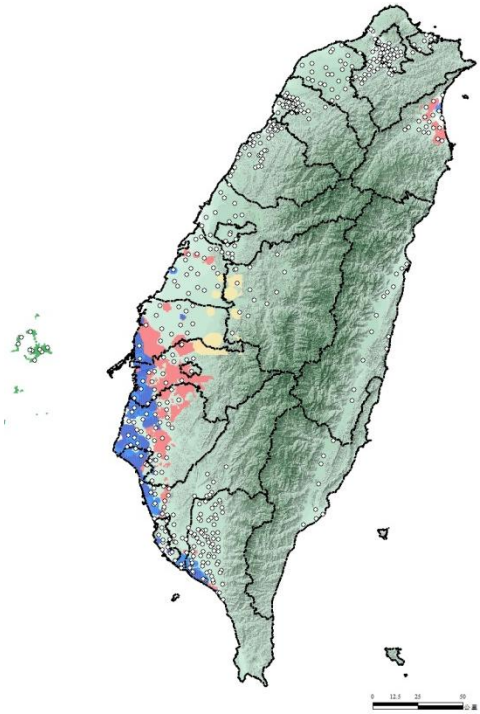

Figure 1. Distributions of monitoring wells (open circle) and groundwater contaminants potential, including arsenic (red), nitrate (yellow), and salinization (blue).

Imminent Environmental Remediation in China

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Background -This paper presents the state of soil and groundwater remediation in China from the perspectives of marketing and business procedures. Recently completed studies by the Chinese Ministry of Environmental Protection and the Chinese Geological Survey indicate soil is severely contaminated in certain areas, and up to 90% of groundwater in the surveyed areas has been contaminated. The areas with contaminated soil and groundwater correlate to dynamic industrial and agricultural activities, mostly in the northern, eastern and southeastern provinces, where over 60% of the population resides. Despite the large number of contaminated sites, the site remediation market in China is only emerging. The challenges include lack of specific laws and regulations, funding, and technical professionals with appropriate remedial equipment.

Activities - Social media has recently exposed environmental issues including smog, heavy metal contaminated rice, and has brought significant public attention to environmental issues in China. Additionally, rapid urbanization has promoted numerous brownfield redevelopments of closed-down and polluting plants in cities. For example, contaminated sites were redeveloped into sports venues for the 2008 Beijing Olympic. As a result, soil remediation has led the environmental market in China. The Chinese government is expected to allocate over $100 billion for soil and groundwater cleanup during the next decade. However, this market and the business practice involved are significantly different from that in western countries.

The driver behind the remediation market in China is more commercial than technical or regulatory compliance. Rapid and massive urbanization demands more land in the already overcrowded cities. Relocating polluting industries, such as iron and steel, petrochemical, fertilizer, and pesticides plants, has become a short-term solution. Most contaminated sites usually have a very short cleanup window (e.g., 3 - 6 months). That leaves most in-situ and sustainable remedial techniques (e.g., MNA, bioremediation) out of place in most cases. The examples illustrate the demand for cost-effective technologies. In addition, the consulting model that has been well adopted in western countries is not applicable in China. The bidding and contracting processes are usually convoluted and confusing. These complications are reflected in each step through the processes of identifying project leads, project due diligence, preparation for bidding, implementation, monitoring, and case closure. Further, not all projects are publically bided, adding to the difficulties.

Conclusions- This paper focuses on the current status of remediation market in China, the challenges it is facing, and the unique marketing practices. Using examples, it also discusses differences in business models in western countries and China, and comments on how western remediation companies could be more productive in Chinese remediation market.

Remediation of Organic Pollutants

Applying Compost Liquid as Surfactant Flushing Agent for Enhancing Removal of Groundwater PCE

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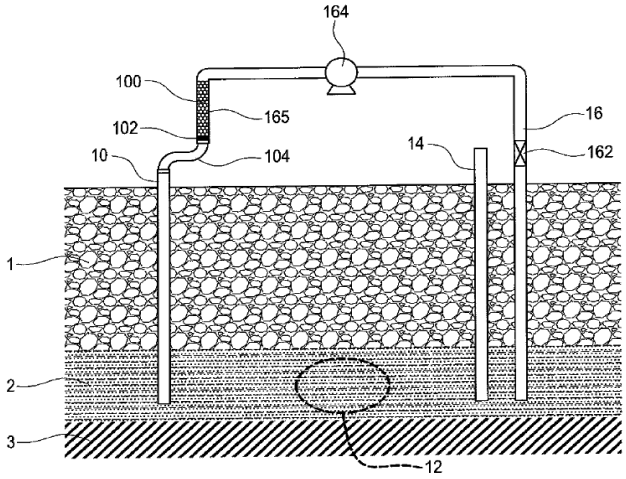
Extended abstract

Surfactant flushing is an effective method to treat groundwater contaminants, but high cost of chemical surfactant agent would limit its application. It has been shown that compost liquid could act as cheap biosurfactant to enhance the solubility of hydrophobic pollutants. In this study, a laboratory scale study was conducted to evaluate the efficiency of compost liquid recirculation system. The study comprised steps of providing an injection column with solid compost sample at an upstream of a contaminated source (with 300 mg/kg of PCE); providing a recirculation device at a downstream of the contaminated source; forming a compost liquid by mixing surface water or groundwater from the recirculation device with the compost solid in the upstream injection column; and groundwater bringing the compost liquid to the contaminated source at downstream. For comparison, the injection column was filled with the same weight of bagasse sample instead of bagasse compost sample to observe the PCE removal efficiency from the source zone.

The column study showed that the compost liquid could remove all PCE from the source zone within 15 days, but there was still around 10 mg/L PCE leaving the source zone if the flushing agent was bagasse liquid after 60 days of operation. On day 72, additional 100 mg/L of PCE was allowed to continuously run through the compost column or bagasse column. No PCE was detected from the compost column after 80 days, but around 10 mg/L PCE was detected from the bagasse column after 180 days of operation. In addition, the concentrations of PCE by-products, such as TCE and DCE, were smaller from the compost column than the bagasse column. Overall, this study demonstrated that compost liquid recirculation system could be a potential green and sustainable remediation technology for groundwater pollutants removal, through the mechanisms of in-situ flushing, in-situ bioremediation, and ex-situ biobarrier.

Keywords: Biosurfactant, Column Study, Chlorinated Ethene, Recirculation System



No	Illustration	No	illustration
1	Unsaturated groundwater zone	2	Saturated groundwater zone
3	Impermeable stratum	10	Injection column
12	Contaminated zone	14	Monitoring well
16	Recirculation device	100	Compost solids
102	Screening device	164	Pump

Figure 1. A system of column study stimulating the method for enhancing removal of groundwater contaminants.

Degradation of TNT, RDX, and HMX Explosives using Permeable Zero Valent Iron Nanoparticles Barrier

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Extended abstract

In situ decontamination of TNT (2,4,6-trinitrotoluene), RDX (1,3,5-trinitroperhydro-1,3,5-triazine), HMX (1,3,5,7-tetranitro-1,3,5,7-tetrazocane) wastewater using zero valent iron nanoparticles (ZVINs) is a promising solution to the cost-effective and eco-friendly remediation techniques. Deployment of ZVINs as reactive agent in a permeable reactive barrier (PRB) system is one of the widely accepted technology for sustainable in situ treatment of contaminated groundwater. In the present study the three different methods of batch experiment, column test, and PRB system were employed to evaluate the treatability efficiency of ZVINs for decontamination of TNT, RDX, and HMX wastewater. The results across three different experimental methods compared and combined to understand the influential parameters lead to better performance of the PRB system (**Fig. 1(a)**). The chemical reaction took place on mixing ZVINs and contaminants, gives batch experiments additional motive power, resulting in a rapid degradation of the explosives. Lack of stirring facilities in column test and PRB, plus interaction of soil and explosives with ZVINs are influential factor effected significant decline in ZVINs treatability from 95% for batch experiments to less than 30%. Furthermore, characteristics of ZVINs technology e.g., kinetics, thermodynamic, and mechanism of action for explosives' remediation were investigated and compared. Results of kinetics studies indicated that TNT was transformed more effectively and rapidly than RDX, and HMX which is in agreement with its lower activation energy. It is likely that both reductive degradation and sorption onto porous iron oxides layer contribute to the disappearance of the explosives. The X-ray spectroscopy results demonstrated that in the process of the reductive reaction, fresh ZVINs turned into core/shell structures with a core of (Fe(0)) and shell of mainly Fe_3O_4. Meanwhile, HPLC/MS experiments revealed that explosives broke into simple substances like CO_2, N_2O, and CH_4 through cleavage of the ring structure (**Fig. 1(b)**) . Primary lab scale studies using different approaches and based on the site characteristics are necessary steps for determination of influential factors that affect ZVINs reactivity and contaminants removal efficiency. More importantly, acknowledgment of the pros and cons of each method would help to improve the design of remediation system. However, development of sustainable remediation approaches requires identification and incorporation of both economical and technological consideration.

Keywords: Zero valent iron nanoparticles, permeable reactive barrier, decontamination, explosives

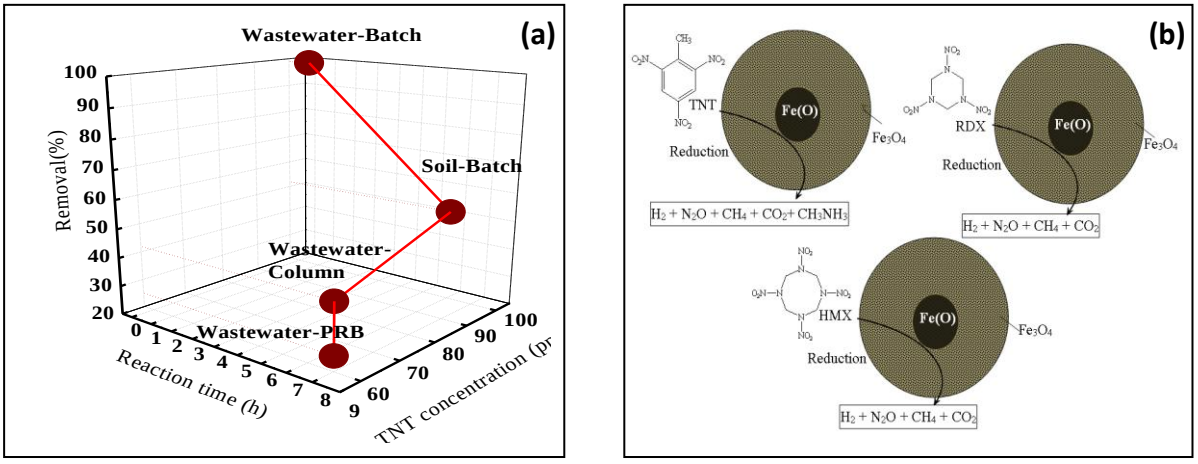

Figure 1. (a) Comparison of the degradation resultsfor the batch experiments, column test, and PRB system. (b) Schematic of TNT, RDX, and HMX explosives degradation by ZVINs.

Adsorption and sequential degradation of brominated flame retardants with zerovalent iron

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Extended abstract

Polybrominated diphenyl ethers (PBDEs), the widely used flame retardants, are emerging toxic contaminants. Their increasing accumulation amount, persistency and toxicity raise a big concern for public safety. The removal kinetics and mechanisms of decabromodiphenyl ether (DBDE) and monobromodiphenyl ether (4BDE) with microscale zerovalent iron (MZVI) and nanoscale zerovalent iron (NZVI) were investigated. Due to higher surface area, NZVI showed about 7 fold higher removal activity than that of MZVI. PBDEs removed by ZVI based upon adsorption and degradation. The degradation pathways of DBDE were proposed according to serial analysis of the species and amount of by-products. ZVI reductively debrominated DBDE into intermediates ranging from nona- to mono-brominated diphenyl ethers (BDEs). Within acid conditions, the degradation rate and debromination activities of ZVI were better than that of alkaline conditions. The adsorption amounts of PBDEs were about 44% on NZVI and 15% on MZVI, increasing with the pH values. The adsorption of PBDEs on ZVI was confirmed through the Fourier transform infrared spectroscopy. Surface adsorption dominated the fast removal of PBDEs with MZVI in the initial stage. Our findings provide evidences for understanding the removal mechanism of PBDEs with ZVI which can facilitate the remediation design.

Keywords: Polybrominated Diphenyl Ethers; Nanoscale Zerovalent Iron; Microscale Zerovalent Iron, Degradation; Adsorption

Zerovalent iron nanoparticles for the remediation of recalcitrant organic contaminants

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Extended abstract

Zerovalent irons (ZVIs) have been used in the remediation of soil and groundwater contamination sites. For recalcitrant organic pollutants, the feasibility of ZVI treatment, the removal mechanisms, and the combination of other technologies should be evaluated. Nanoscale ZVI (NZVI) particles we synthesized are used to investigate the effect of material properties and environmental factors on the reduction kinetics and degradation mechanisms of recalcitrant aromatic contaminants such as Congo red (CR) and some halogenated organic compounds including polybrominated diphenyl ethers (PBDEs), hexachlorobenzene (HCB), pentachlorophenol (PCP), and hexabromocyclododecane (HBCD) (Shih et al., 2011ab; Shih and Tai, 2010; Shih and Tso, 2012; Su et al., 2012; Su et al., 2013; Tso and Shih, 2014). Adsorption plays a role on the removal of PBDEs on NZVI (Shih and Tai, 2010). Pd/Fe bimetallic particles can effectively remove HCB and PCP (Shih et al., 2011a). The environmental effects on the degradation of HCB and PCP were also studied. Furthermore, the addition of cetyltrimethylammonium bromide, CTAB) can enhance the dehalogenation of PCP with Ni/Fe bimetallic nanoparticles (Lin and Shih, accepted). On the other hand, the great longevity of microscale zerovalent iron (MZVI) on the PBDE degradation was found (Peng et al., 2013). The combined effects of MZVI and anaerobic microbes in decabrominated diphenyl ether (DBDE) result from that MZVI leads to the enrichment of heterotrophic microbial populations bearing nitrate- or iron-reducing activities. The interaction between MZVI and microbes contributed to the synergistic effect (Shih et al., 2012ab). The fast decolorization of CR with NZVI was found; however, the mineralization of CR with NZVI was very low. Sequential NZVI/H_2O_2 processes can effectively decompose CR due to the Fenton reaction through ferrous ions from the oxidized NZVI (Shih and Tso, 2012). Our experimental results contribute to a better understanding of aromatic contaminant degradation and serve as a useful reference for remediation design and prediction of treatment efficiency of recalcitrant contaminants with ZVIs.

Keywords: Nanoscale zerovalent iron (NZVI), halogenated organic compounds, adsorption, dehalogenation, mineralization, synergistic effect.

In-Situ Decontamination of DNAPLs in Groundwater by Polymer-coated Zero-valent Iron Nanoparticles

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Extended abstract

In Taiwan, remediation of sites contaminated by dense non-aqueous phase liquids (DNAPLs), especially chlorinated organic compounds, is a significantly priority in the environmental field because of their widespread use in many applications. Therefore, the main objectives of the present study were to prepare surface-modified zero-valent iron nanoparticles (ZVINs) by coating polymeric nanofilms and *in-situ* DNAPLs-contaminated groundwater remediation. By FE-SEM and TEM analyses, spherical ZVINs with a diameter of 20-120 nm were measured (Figure 1). In addition, polymer/ZVINs in the form of spherical particles with diameters ranged of 20-80 nm were also measured. The main species on ZVINs and polymer/ZVINs are FeO, Fe_3O_4, and $FeSO_4$ measured by ESCA. The EXAFS data showed that the Fe atoms in polymer/ZVINs reacted with DNAPLs coordinated by primarily Fe–O with a bond distance of 1.95 Å and a coordination number of 4.39 (Figure 2). These results indicated that the ZVINs and polymer/ZVINs can convert 99% of TCE, PCE, and 1,2-DCE solutions to nontoxic compounds. The reduction rates of Cl-DNAPLs were 1,2-DCE > TCE > PCE solution. In addition, the conductivity data of suspended polymer/ZVINs solution and sampling groundwater were similar using RIP (Figure 3). It indicated that the combinative technology of floating surface-modified ZVINs and RIP would be economically and environmentally attractive for DNAPLs decontamination.

Keywords: Zero valent iron nanoparticles, DNAPLs, chemical reduction, injection method, groundwater decontamination

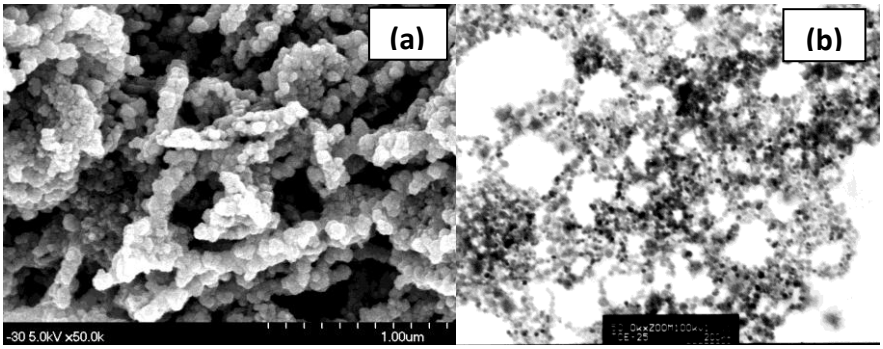

Figure 1. (a) FE-SEM and (b) TEM microphotos of ZVIN coated polymer thin film.

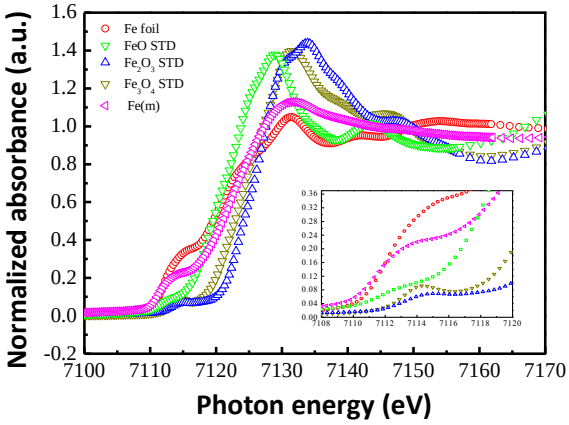

Figure 2. XANES spectra of polymer/ZVINs and Fe standards for Fe K-edge.

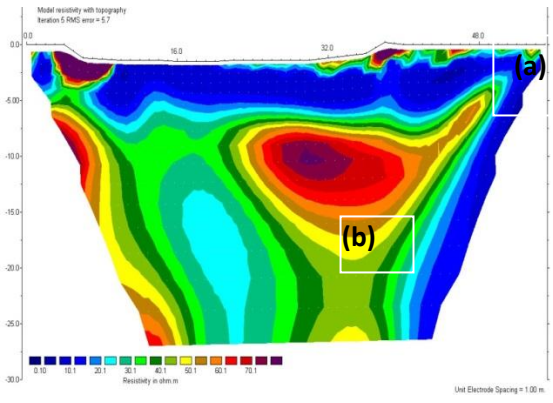

Figure 3. Concentration profiles of DNAPLs decontaminated by polymer/ZVINs and measured using RIP technique.

The reduction of hexabromocyclododecane (HBCD) by zerovalent iron and bimetallic nanoparticle aggregates

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Extended abstract

Hexabromocyclododecane (HBCD), an emerging contaminant, is a brominated aliphatic cyclic hydrocarbon used as a flame retardant in various products. Due to its persistence and high usage in many products, HBCD has been widely detected in the environment. Since a relatively high level of HBCD measured in human, a fast and effective removal technology of HBCD is urgent. In this study, nanoscale zerovalent iron (NZVI) aggregates were first used to treat HBCD and evaluated its removal under different geochemical conditions. HBCD was almost removed from aqueous solutions by NZVI with 5 g/L iron loading in 30 min with a k_{SA} was 4.22×10^{-3} L m^{-2} min^{-1} (Fig. 1, Tso and Shih., 2014). The increase of iron dosage and temperature enhanced the removal reaction. The activation energy of the removal of HBCD by NZVI was 30.2 kJ mol^{-1}, suggested that a surface-chemical reaction was occurred on NZVI while electron transfer took place. A pathway for debromination of HBCD had been proposed that HBCD diffused through the solution to the Fe^0 nanoparticles and adsorbed on Fe^0 surface. Electrons were transferred from the Fe^0 nanoparticles to the HBCD molecule forming intermediated products with less bromide. Initial pH effect was unobvious on the degradation efficiencies of HBCD with NZVI. Three common dissolved groundwater electrolytes (NaCl, $NaNO_3$, and $NaHCO_3$) decreased the reaction kinetics and efficiency of NZVI. The degradation kinetics of HBCD in the presence of Cl^-, NO_3^-, and HCO_3^- was slower than those without anions in the order of: pure water $>Cl^-> NO_3^- \fallingdotseq HCO_3^-$. The inhibition effect of these electrolytes could result from the possible complexation of anions with oxidized iron surface. The oxidized sites on NZVI and oxidized species of iron also contribute the removal of HBCD through the adsorption on NZVI from aqueous solutions. These findings suggest NZVI can effectively treat HBCD in the environment.

Keywords: Hexabromocyclododecane (HBCD), nanoscale zerovalent iron (NZVI), nanoparticle aggregates, groundwater electrolytes.

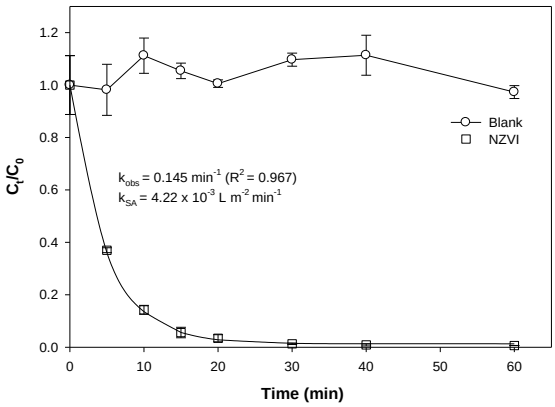

Figure 1. Degradation of HBCD with NZVI aggregates.

Decolorization and mineralization of Congo red with zerovalent iron nanoparticles

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Extended abstract

Azo-dye compounds are widely used in the textile industry, mostly discharged in industrial wastewater, and contaminated soils. In this study, we performed chemical reduction of azo-dye Congo red (CR) using laboratory synthesized nanoscale zerovalent iron (NZVI) particles to exam the effects of temperature and pH on the decolorization kinetics and the decomposition products. The decolorization of CR with NZVI undergoes a much faster reaction than that with microscale ZVI (MZVI, Shih and Tso, 2012). The decolorization behaviors of CR with NZVI follow the pseudo-first-order kinetics. Increasing the dose of NZVI enhanced the decolorization rate of CR. The reaction rate constants did not decrease significantly with increase in pH for CR. It is also found that the reaction rate increased slightly with increase in temperature. The activated energy is needed for the removal of CR with NZVI is smaller than that using MZVI (4.8 and 13.9 kJ mol^{-1}, respectively), suggesting an insignificant effect of temperature on decolorization reaction. The intermediate analysis suggests the presence of broken azo bonds in CR with NZVI surface. However, the mineralization of CR with NZVI is very low. The sequential NZVI/H_2O_2 process can decompose CR effectively due to the Fenton reaction. The combination of reduction power of NZVI and its oxidized ions with H_2O_2 can be an alternative for treating azo-dye wastewater and dye contaminated soils.

Keywords: Azo-dye, zerovalent iron nanoparticles, dosage, pH, temperature.

Health Risk-based Remediation Technology

The Improvement of Transformer Insulation Oil Pollution Site

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Extended abstract

The site had used as the waste storage warehouse belonging to Taiwan Power Company. And the possible pollution sources in this site could be the leakage of the transformer insulation oil. According to the investigation from groundwater monitoring wells, the concentration of TPH_d was 19.6 mg/L which was over the value of groundwater control standards (1.37 mg/L). The improvement methods in this site could be categorized into three means: soil excavation from unsaturated zone, saturated soil surfactant flushing, and in-situ chemical oxidation operation. The treatment started with the excavation of unsaturated soil. Due to poor correlation between the actual concentration by laboratory measured and the measurements of TPH test kit, it needed field personnels's professional judgment to screen the excavation of the soil. The second stage was using surfactant flushing system to wash out the adherence of underground soil pollutants in order to reach the goals of improvement. The Fenton like oxidation process was adopted at the third stage. After these processes, the concentration of pollutants was decreased and mineralized into water and CO_2. The verification in groundwater indicated that the maximum concentration of TPH_d was under the control standards. The pollution concentration is lower than that was before improvement. That is to say that the goal of improvement has been achieved.

Keywords: insulation oil, soil excavation, surfactant, in-situ chemical oxidation

Establishment the system platform of risk management for abandoned factories in Taiwan

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Extended abstract

Previously, the lack of environmental awareness and stringent environmental protection regulations resulted in waste mismanagement during plant operations, causing soil and groundwater to be heavily polluted. In Taiwan, multiple incidents of soil and groundwater pollution in factories that have closed down were exposed, such as the chlorinated organic solvent pollution in the soil and groundwater of the Radio Corporation of America (RCA) in Taoyuan and mercury and dioxin-contaminated soil in China Petrochemical Development Corporation (CPDC) An-Shun site. These incidents have attracted the attention of Taiwanese citizens and the Environmental Protection Administration (EPA). In addition, the adverse effects abandoned factories exert on people and the environment (e.g., pollution dispersion caused by waste mismanagement in abandoned factories, lack of management in factories, or land development) are comparable to those generated by an operating factory. Therefore, the EPA initiated a series of investigation and management on abandoned factories nationwide from 2004.

According to the Industrial Development Bureau of the Ministry of Economic Affairs, 120,000 factories had closed down prior to January 1, 2005, as well as the amounts of high contamination potential factories were about 42,000 by screening. Therefore, the EPA developed the "Taiwan's abandoned factory environmental risk screening mechanism" referring to the guidance of Europe and the United States that combines sources of pollution, environmental transport, receptor exposure to screen risk level of abandoned factories. Furthermore, the EPA established "The system platform of the environmental risk management for Taiwan's abandoned factory" following the risk screening mechanism and constructing the management information system (MIS) and Geographic Information System (GIS) database. The environmental risk platform is composed of three sections: (1) algorithm module, which performs automated computation according to the screening mechanism; (2) pollution potential module, which assesses the pollution potential of abandoned factories based on their current situations; and (3) environmental risk calculation, which calculates the pollution potential of specific sites. Overall, this integrated system displays the risk level of the abandoned factories (red, orange, yellow, or green lights) and a summarized spatial distribution of these lights according to the GIS database. Moreover, this system enables users to acquire historical records of sites, the latest aerial images, relevant image and information of an abandoned plant, thus affording users with insights into the potential risks of abandoned factories in Taiwan to facilitate their decision-making processes.

Keywords: abandoned factories, soil and groundwater pollution, environmental risk management

Figure 1 the system platform of risk management for abandoned factories

Sampling, Monitoring and Evaluation of site

Sampling, Monitoring and Evaluation of site

The Course of Protecting Agricultural Land from Heavy Metal Pollution in Taiwan

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Extended Abstract

Soil is the ultimate sink, which absorbs various pollutants from air, water, and solid wastes. Crops can uptake not only nutrients but also pollutants, such as heavy metals, from soil, and will impact on human via food chains. Concerning the safety of agricultural products, evaluation of heavy metals in agricultural soil is required. In 1982, the cadmium-tainted rice incidents first burst out in Taoyuan County. To protect people's health, the Environmental Protection Administration of Taiwan (Taiwan EPA) conducted a systematic investigation of farmland soil heavy metal content nationwide. After two decades of grid soil sampling, when "Soil and Groundwater Pollution Remediation Act" was implemented in 2000, the "319 Hectares of the Farmland Pollution Survey" and the follow-up monitoring and controlling programs continued to launch. The main cause of farmland pollution has concluded as chronically using polluted irrigation water. Due to poor land-use planning, industrial plants in agriculture areas discharged their wastewaters directly or indirectly into farmlands through irrigation channels. The irrigation channel system was well established in Taiwan since the 17th century, with its total length of 69,294 km, covering about 580,000 ha. Approximate 20 thousand tons water used as irrigation for rice cultivation per crop season per ha. Thus, adopting the concept of irrigation system helps precisely addressing soil heavy metals pollution, revealing information related to the underlying process involved in pollution and providing a more realizable unit for taking improvement or remedial action. All the follow-up investigation and management, taking GIS as a platform, integrated soil survey results cross ministries and gathered scientific know how to quantify and classify above massive database; then established the heavy metal background concentration and the risk map of farmland contamination, and constructed "Taiwan farmland heavy metal pollution evaluation system". With this system, the authorities of concerns could speed up efficiency and make better decisions. The ultimate goal is to prevent prime farmland in Taiwan from being polluted and to achieve sustainable development in agriculture even facing new challenge of pollutants from high-tech industry.

Keywords: farmland, heavy metals, irrigation, soil contamination, evaluation system.

The Application of Multi-Increment Sampling to Characterization of Pb on Agricultural Land

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Extended abstract

Multi-Increment Sampling (MIS) is a structured sampling protocol, first published in 2003 by the Engineer Research and Development Center of the United States Army Corps of Engineers. The methodology aims to reduce data variability and increase sample representativeness when compared to conventional discrete sampling strategies. It is applicable to a wide range of sampling objectives, analytes, and circumstances, such as explosive compounds in soil in both field sample collection and laboratory subsampling. It is recommended that (1) at least one kilogram for each soil sample be collected to overcome compositional heterogeneity; (2) at least 30 grab samples be collected to overcome distributional heterogeneity within the decision unit; (3) decision unit be designed within 25 to 10,000 square meters to be adequately characterized using MIS.

In this study, field sampling experiments were conducted on agricultural lands at two locations within Taiwan (Sites A and B). The purpose of this study was to develop practical sampling strategies to reliably estimate mean concentrations of Pb found in surface soil near factories. Surface soil samples (10 – 15 cm) were collected from Sites A and B using discrete and MIS strategies, followed by XRF analysis for Pb. These two sampling strategies estimated similar average Pb concentrations in both Sites A and B. The standard deviations of MIS data were estimated to be 7.6 and 120.9 for Sites A and B, respectively, which indicated that the agricultural lands studied differed in the mode of contaminant transport. MIS was used to reduce the variance between field sample replicates and to enhance sample representativeness. Based on these criteria the results indicated that a single or a few discrete samples did not provide representative data for these types of sites. However, samples built from at least 30 increments provided data that were sufficiently representative to allow for the estimation of Pb mass loading in surface soil and to characterize the contamination on agricultural lands.

Keywords: Lead (Pb), multi-increment sampling, MIS, agricultural land

Impact of natural organic matter on the redox reaction of arsenic in water

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Extended abstract

Impact of natural organic matter (NOM) on the change of arsenic (As) and their adsorption behavior with iron-based adsorbents in various water sources is studied. Commercial humic acid (HA) was used as model NOM, and iron-oxide-coated diatomite (IOCD) and iron hybrid anion exchange resins, were used as adsorbing media. Based on X-ray absorption near edge structure (XANES) spectroscopy analysis, the As species was recognized to transfer only in aqueous phase, no speciation change was observed once As adsorbed onto adsorbents. In de-ionized water, the interference of tested adsorbents for the redox of As can be ignored, while the As is obviously shifted in the presence of NOM (commercial HA), especially for the oxidation of arsenite (As(III)) to arsenate (As(V)). In addition, a further identification of the interaction between NOM and As species (without adsorbents) were conducted by NOM-laden natural waters (lake and groundwaters). The As(III) or As(V) was spiked into collected waters followed by micro-filtration (MF), ultra-filtration (UF), or nano-filtration (NF). NOM possessed much more stronger and stable oxidative ability for As(III) than that of reduction for As(V). Based on the spectra of high performance size exclusion chromatography (HPSEC), the oxidation of As(III) might be mainly attributed to the molecular distribution of NOM compared to its concentration. Meanwhile, results of X-ray photospectrometry (XPS) also indicated that organo-As could be possibly produced by a complexation of biopolymers and low molecular weight (LMW) acid and humics of NOM with both As species.

Keywords: Natural organic matter, arsenic, iron-based adsorbent, oxidation, reduction

Application of qPCR for Detection of *Dehalococcoides* sp. in Groundwater Contaminated with Chlorinated Compunds

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Extended abstract

Highly chlorinated ethene compounds have been extensively used as solvents. Leaking and improper disposal of these solvents has resulted in widespread contamination of soil and groundwater. Remediation of chlorinated solvents poses a difficult challenge because they are highly recalcitrant to biodegradation. Common chlorinated compounds, such as tetrachloroethene (PCE) and trichloroethene (TCE), can be sequentially dechlorinated to dichloroethene (DCE), vinyl chloride (VC) and final products, ethane and carbon dioxide (CO_2), by *Dehalococcoides* sp. and other dechlorinating bacteria. Recently developed molecular biology techniques, especially quantitative PCR (qPCR) methods, have been widely utilized to detect and monitor microbes responsible for degradation of chlorinated pollutants. This study used the qPCR technology and specific primers to quantify the abundance of *Dehalococcoides* spp. in YK and TK sites polluted with chlorinated solvents. Results show that the 16S rRNA gene concentration of *Dehalococcoides* spp. increased from 10^2 – 10^4 copies / ml to 10^7 – 10^9 copies / ml in groundwater after one-year remediation in the YK region. For TK region, the increase of total bacteria was observed after a 2-month treatment; while there is no significant increasing for *Dehalococcoides* spp. We demonstrated that the quantitative PCR method and specific primers can be used to monitor the concentration dynamics of *Dehalococcoides* in groundwater and the obtained results may be further utilized for the evaluation of the reductive dechlorination potential of contaminated sites.

Keywords: Chlorinated ethenes, *Dehalococcoides* spp., Quantitative PCR (qPCR)

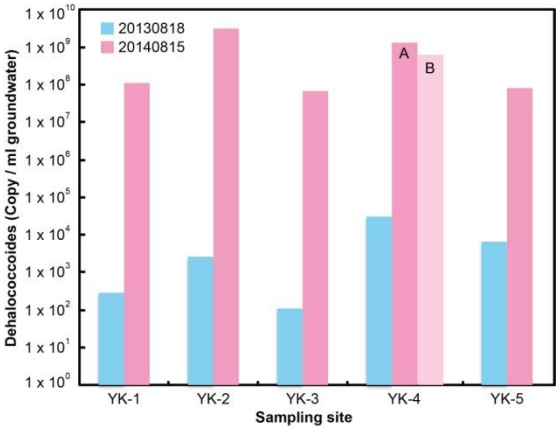

Figure 1. The concentration of *Dehalococcoides* 16S rRNA gene at five sampling sites in the YK region during one-year remediation.

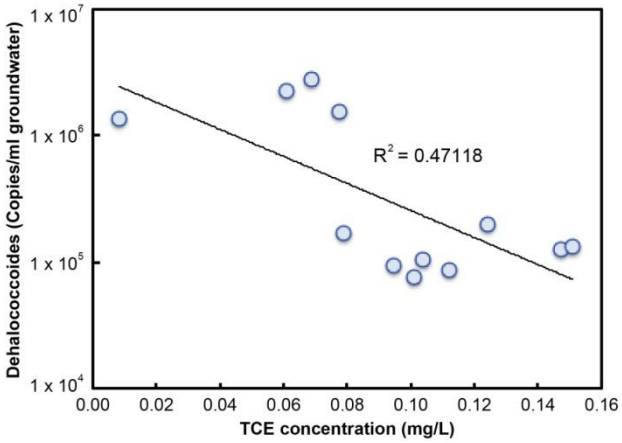

Figure 2. Correlation between the concentration of trichloroethylene (TCE) and *Dehalococcoides* 16S rRNA gene in the TK region.

Prediction of Cu and dissolved organic carbon (DOC) sorption onto kaolinite in field pH range

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Extended abstract

Application of composts can promote soil physical, chemical, and biological properties. However, heavy metal movement in soils should be evaluated while applying metal-enriched composts such as swine manure compost (SMC). Dissolved organic carbon (DOC) was known to have high affinity to associate with Cu and may remain more Cu in soil solutions in certain soil pH conditions. However, the overall vision of the DOC-Cu-clay interactions in wide pH range is not clear because of the complicated interactions between DOC, metals, and surfaces on clay minerals. Therefore, it is difficult to describe the Cu retention by the solids in clay-DOC suspensions using an simple model since the properties of DOC solutions are usually depend on their sources and the surface properties can be significantly altered after adsorption of DOC or DOC-Cu complexes.

In this study, kaolinite (s:w=1:25), Cu(II) (0-600 μM), and the DOC solution (0-16 mM) extracted from a commercial SMC were used to identify the reactions between each two of the materials via batch experiments in field pH range (pH 3-10). In the DOC-kaolinite suspensions, the equilibrium DOC concentration ($[DOC]_B$) was found to be an function of total TOC ($[TOC]_T$) and pH which was $[DOC]_B = (-0.0057\ pH^2 + 0.1139\ pH + 0.3470)$; (Eq. 1). In the 10 mM DOC solutions with 37.5-600 μM of Cu, a part of Cu and DOC precipitated. The relation between final Cu concentration ($[Cu]_B$), final DOC concentration ($[DOC]_B$) and initial Cu concentration ($[Cu]_T$) was found as $[Cu]_B \cdot [DOC]_B = 0.0088\ [Cu]_T$; (Eq. 2), which is independent with pH. Assuming that Cu associated with DOC much more strongly than with kaolinite and DOC sorption onto kaolinite was not obviously affected by Cu, Eq. 1 and Eq. 2 can be combined as $[Cu]_B = m\times\{0.0088\ [Cu]_T / (-0.0057\ pH^2 + 0.1139\ pH + 0.347)\times [DOC]_T\}$; (Eq. 3), whereas "m" implies an overall effect of interactions on Cu sorption in a DOC-Cu-Clay system. Eq. 3 was used to fit the experimental data with the initial condition of 10 mM DOC, 4% of kaolinite, 40-320 μM of Cu, pH 3-10, and controlled ionic strength by 0.025 M KNO_3 (Fig. 1a). The coefficient "a" in Eq. 3 was then estimated to be 0.593 and a high coefficient of determination was derived (R^2 = 0.973; Fig. 1b). The empirical equation established in this study could well describe the Cu sorption by kaolinite as affected by DOC in field pH range. However, more studies on different clay minerals, various sources of DOC, other metal elements, and different initial conditions are certainly needed.

Keywords: Copper (Cu); Dissolved organic carbon (DOC); Kaolinite; Sorption; Prediction

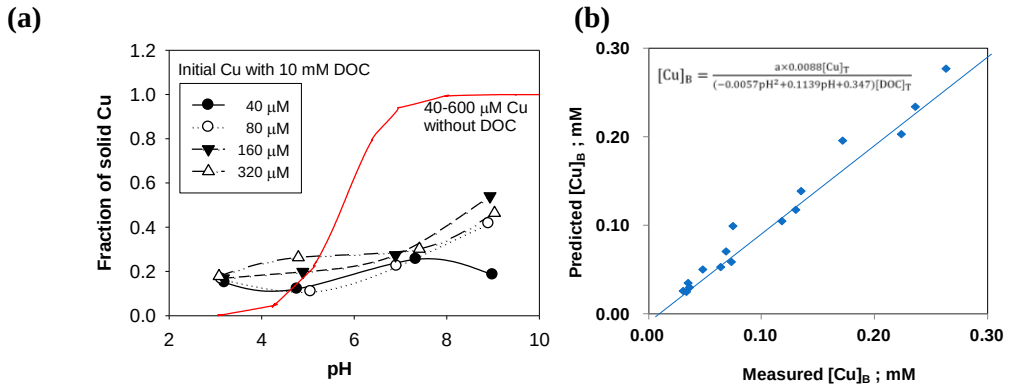

Fig. 1. Cu sorption onto kaolinite at pH 3-10 as affected by 10 mM DOC. Initial Cu: 40-600 μM. IS: 25mM KNO_3. S:W = 1:25. (a) experimental data; (b) fitting result using Eq. 3.

Assessment of Acute Toxicity of Explosives in the Environment

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Extended Abstract

Leakage of explosives were commonly found in manufacture, dumpsites, military exercises, transportation and arsenals in military facilities. Thus, these will result in contamination of soil and groundwater and aquatic environment. Four target compounds include 2,4-dinitrotoluene (2,4-DNT), 2,4,6-Trinitrotoluene (TNT), cyclotrimethylene-trinitramine (RDX) and cyclotetramethylene-tetranitramine (HMX) were studied to evaluate acute toxicity in the terrestrial and aquatic environment. Test species including Neocaridina shrimp (*Neocaridina denticulata*), amphipod (*Hyalella azteca*), carp (*Carassius auratus*), silkworm (*Tubifex hattai*), and earthworm (*Eisenia fetida*) were used in acute toxicity test. The results indicated that the LC_{50} of 2,4-DNT onto neocaridina shrimp was measured to be 31.2 mg/L. The LC_{50} of 2,4-DNT onto amphipod was estimated to be 6.78 mg/L. No apparent toxic effect was observed for terrestrial species exposed to explosives. Earthworms were not affected by toxicity effects of RDX at concentration level of 58.6 mg/L and 5.81 mg/L of HMX. No toxicity effect was observed for neocarina shrimp at 6.83 mg/L of HMX. Also it was observed that carps were not affected by toxicity effects of 6.50 mg/L of HMX. The information generated in this study will assist risk based decision making process when managing explosive contaminated sites.

Key word: Explosives, 2,4-DNT, TNT, RDX, HMX, Acute toxicity test.

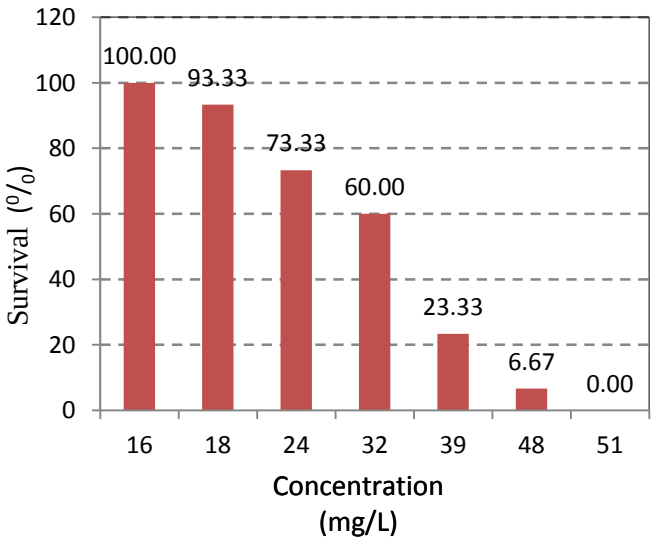

Figure 1. Acute toxicity test of 2,4-DNTonto *neocaridina* shrimp.

Evaluation of Preferential Groundwater Flow Using the Heat-pulse Flowmeter at a Contamination Site

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Extended abstract

How to delineate the vertical distribution of hydraulic conductivity or the preferential flow in a heterogeneous aquifer is a challenge to the investigation for a contamination site. As heat-pulse flowmeter provides a promising direct measurement technique for measuring the flow velocity in a borehole, we adopted it to test the feasibility of detecting permeable section in a contaminated aquifer. Laboratory tests were conducted first to verify the measurement results and we developed a calibration method. Field tests were then conducted in the NTU and Heshe Hydrogeological Experimental Well Station. Test results indicated that the hydraulic conductivity varies with depth and the heat-pulse flowmeter can operate well in both pumping and injection condition with similar results. The position of the highly permeable zone can be identified within the range of 25 cm. The measurement results in Heshe showed that the flowmeter can locate the permeable fractures and preferential flow paths. Water flow in borehole is produced primarily from just a few fractures. A pilot test was conducted at two wells with a depth of 12 meters in the Kaohsiung Refinery of CPC. The hydraulic conductivity of the most permeable layer obtained from two wells is about 0.95 m/min and 1.31 m/min respectively, which are 5.5 and 7.6 times greater than the equivalent hydraulic conductivity of the whole aquifer suggesting that contaminant migration rate could be underestimated. Combining the measured results of heat-pulse flowmeter and the information obtained from different measurement techniques performed in the field, it is possible to characterize the preferential groundwater flow more precisely and efficiently.

Keywords: groundwater contamination, flowmeter, pilot test, site characterization

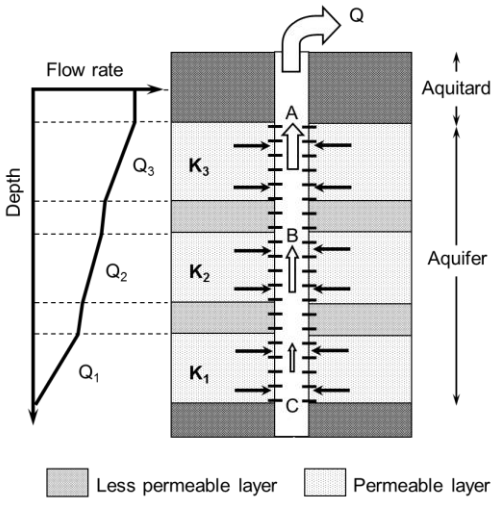

Figure 1. Conceptual model of ground water flow in a heterogeneous aquifer and vertical distribution of flow rate in the wellbore under pumping conditions.

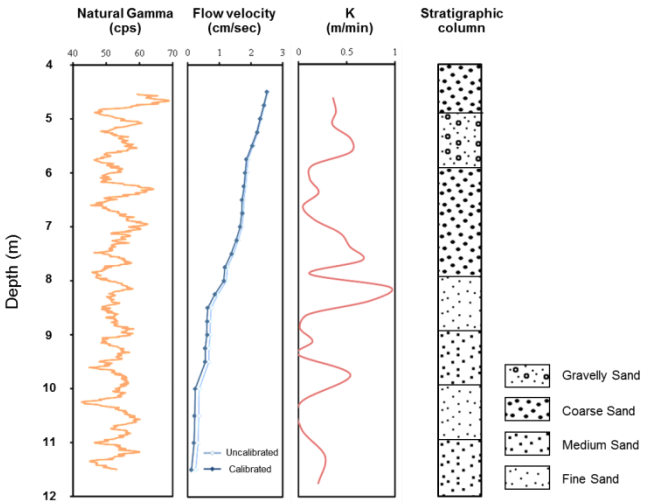

Figure 2. The vertical distribution of flow velocity measured by the heat-pulse flowmeter and the estimated hydraulic conductivity in the Kaohsiung Refinery of CPC (Well-W).

Evaluation of anaerobic reductive dechlorination of trichloroethene by using laboratory scale columns

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Extended abstract

TCE is an organic solvent which commonly used in many industries and facilities for metal cleaning, degreasing…etc. It has been considered as adverse effects on central nervous system, immune system and endocrine system in human body. When TCE spilled into the environment, the characteristic of greater specific gravity and low solubility in water cause it to be absorbed into the soil and then sink into the groundwater. Recently, in situ bioremediation is an emerging technology which creates anaerobic conditions to enhance reductive dechlorination in groundwater and promote the sequential biotransformation of TCE to DCE, VC and ethene. In this study, the biodegradability from the soil of TCE-contaminated sites was evaluated. Two stages of tests were conducted in soil, which were column tests and batch bioreactor incubation. In columns test, the influent of TCE-contaminated groundwater was controlled 1.5 (ml/min) to simulate in situ environment passing through soil which try to investigate the period of anaerobic dechlorination environment. After 52 days of incubation, ORP could decrease to -132 mV. For the batch bioreactor was contained soil and carbon source which try to enrich microorganism and then gradually added different concentration of TCE. After 160 days of incubations, TCE was found that could degrade to DCE. The TCE degradation rate of 1801 (μg TCE/day) can be achieved at 190 days. VC was slightly accumulated and no ethene was found during incubations. However, DCE and VC were slightly accumulated during column tests. In summary, with the two-stages of tests in this study, approximately 95% of TCE can be removed to DCE. However, the biodegradation of DCE became a rate limit step during batch experiment.

Keywords: TCE, in situ bioremediation, column tests

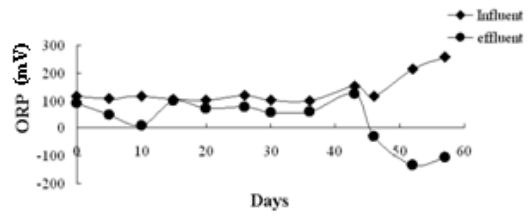

Fig1. The ORP of influent and effluent in columns test during 57 days

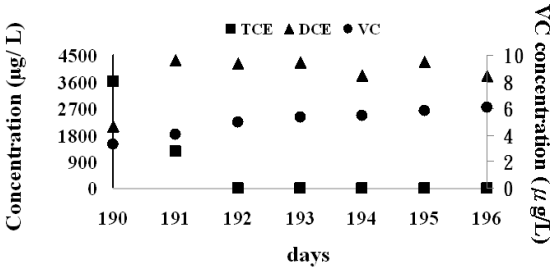

Fig.2 The concentration of TCE, DCE and VC in batch bioreactor enrichment from 190 to 196 days

Simulating the Effect of Infiltration from River on Groundwater Quality

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Extended abstract

In order to understand the effect of surface water quality infiltration on groundwater quality and the resulting health risk effect, a case study was conducted using the downstream section of a major river in central Taiwan. The study area was chosen because it receives a wastewater discharge from one the industrial parks in central Taiwan. The scenario of the study was as the following: (1) the discharge point is on the south bank of the river about 2 Km from the point where the river discharge into the Taiwan Strait; (2) the chemicals of the discharged water enter the groundwater by means of infiltration through the bottom of the river; and (3) the groundwater is used for irrigation and domestic purposes. A groundwater and solute transport model for the above-mentioned scenario was constructed and calibrated. The calibration uses groundwater elevations in five monitoring wells. To obtain acceptable results, the hydraulic conductivity of the simulated area is divided into 33 zones. During calibration, the hydraulic conductivity of the simulated area is adjusted so that the predicted groundwater elevation approached the observed values. The criterion for the calibration is for the root-mean-square-error (RMSE) of the groundwater elevations to be less than 1.0. After calibration, 4 sets of data were used to validate the model resulting in RMSE less than 1.0. The solute transport model used the calibrated model and a pumping well to generate a groundwater flow field. The pumping well is to simulate the scenario when groundwater is drawn during irrigation season for rice growing. Three chemicals were simulated as the "concerned chemicals": arsenic, molybdenum, and ammonia. In addition, electrical conductivity was also modeled. The concentration distributions of the simulated chemicals over the study area were obtained using 30 years as the duration of transport. The results of maximum simulated concentrations were used to calculate the health risk assessment. The carcinogen risk indicated acceptable risk increase (less than 1 millionth) by the infiltration of the discharge water. However, the non-carcinogenic health risk exceeds acceptable lever (> 1) if oral consumption of groundwater was taken into account. Ammonia is the major contribution to this risk effect followed by molybdenum. However, the non-carcinogenic health risk is lower than 1 if oral consumption of groundwater is excluded from the calculation. The results of this study show numerical simulation of groundwater and solute transport combined with adequate monitoring scheme of groundwater is effective in predicting the health risk effect of chemicals found in discharged water.

Development of Early-warning Lights Classification Management System for Industrial Parks

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Extended abstract

This paper presents the early-warning lights classification management system for industrial parks promoted by the Taiwan Environmental Protection Administration (EPA) since 2011, including the definition of each early-warning light, objectives, action program and accomplishments. All of the 151 industrial parks in Taiwan were classified into four early-warning lights, including red, orange, yellow and green, for carrying out respective pollution management according to the monitoring data of soil and groundwater quality, regulatory compliance, and regulatory listing of control site or remediation site. The Taiwan EPA set up a priority list for high potential polluted industrial parks and investigated their soil and groundwater qualities based on the results of the light classification and pollution potential assessment. In 2011-2013, there were 44 industrial parks selected and carried out different investigation, such as the early warning groundwater well networks establishment and pollution investigation/verification for the red and orange-light industrial parks and the environmental background survey for the yellow-light industrial parks. Among them, 22 industrial parks were newly or continuously confirmed that the concentrations of pollutants exceeded those in soil or groundwater pollution control standards. Thus, the further investigation, groundwater use restriction, listing of pollution control site or remediation site, and pollutant isolation measures were implemented by the local environmental protection and industry competent authorities; the early warning lights of those industrial parks were proposed to adjust up to orange or red-light. Up to the present, the preliminary positive effect of the soil and groundwater quality management system for industrial parks has been noticed in several aspects, such as environmental background information collection, early warning of pollution risk, pollution investigation and control, information integration and application, and inter-agency collaboration. Finally, the work and goal of self-initiated quality management of industrial parks will be carried out on the basis of the inter-agency collaboration by the classified lights system of early warning and management as well as the regular announcement of the status of each industrial park.

Keywords: Industrial park, soil and groundwater quality management, early-warning lights classification, SOP for reporting and treatment of monitored abnormal events

Comparison of Membrane Interface Probe and Laser Induced Fluorescence on Site Pollution Investigation and Assessment

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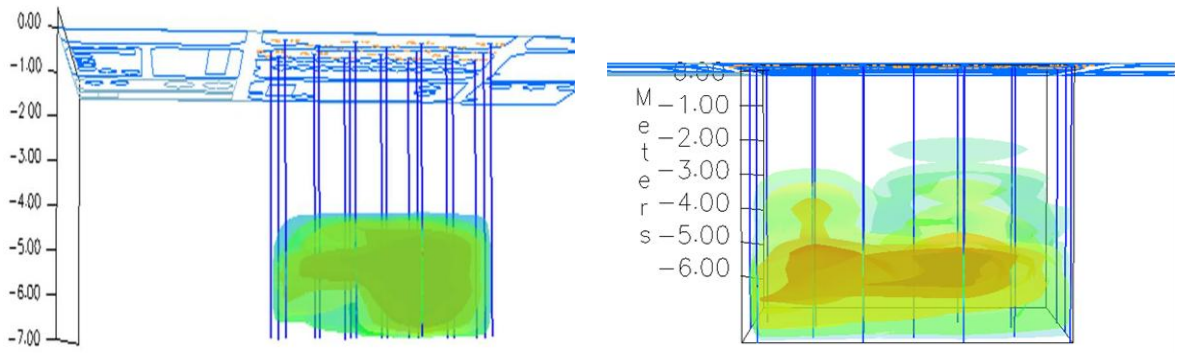
Extended abstract

This selected study area is one soil and groundwater remediation site contaminated with potential multiple sources of petroleum leakages. In-situ continuous laser induced fluorescence (LIF) detection was applied to delineate the distribution of free-phase petroleum contaminants, and in-situ continuous membrane interface probe (MIP) detection was synchronously applied to examine the distribution of dissolved contaminants as well. The principle of LIF detection is based on fluorescence reactive property of the specimen, and thus each contaminant own its specific fluorescence characteristics for allowing species recognition. The result of LIF detection found that the major NPAL contaminant residuals presented in the depth range of 4.2 m to 6.8 m. Besides, the detected NAPL contaminant residuals can be classified into 3 types when comparing their LIF characteristic fluorescence spectra. The principle of MIP detection is based on thermal evaporation property of the specimen, and thus non-volatile compounds are not suitable for MIP detection. The result of MIP detection found that the major dissolved contaminant plume distributed from the depth of 1.8 m to 6.8 m deep. As shown in Figure 1, site conceptual model of contaminant distribution can be established either by LIF detection or MIP detection. LIF is able to detect heavy fuel components in groundwater domain, and MIP is able to discover light fuel components in vadose zone. This study successfully demonstrated the advantages of LIF detection to track potential leakage sources. One drawback of LIF detection is that the fluorescence characteristics of light fuel components might be overlaid by heavy fuel components, and MIP detection can be employed to conquer this drawback. One drawback of MIP detection is its less sensitivity to heavy fuel components, which just can be compensated by LIF detection. The uncertainty of site investigation can be reduced through LIF detection associated with MIP detection.

Keywords: Laser induced fluorescence (LIF), membrane interface probe (MIP), site conceptual model, fluorescence characteristics, thermal evaporation



(a) LIF detection (b) MIP detection

Figure 1. Site conceptual model of contaminant distribution established by (a) LIF detection, (b) MIP detection.

Inorganic Nitrogen Distribution in Groundwater in Southwestern Taiwan and Strategies to Prevent Its Contamination

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Extended abstract

Appling fertilizers can increase yield of crop evidently. However, the surplus nutrient, especially nitrogen not absorbed by plants may increase environmental impact. The quality of groundwater might be affected by the nitrate leaching under fertilization. To realize the status of groundwater affected by fertilization, the groundwater quality has been investigated in the main agricultural area of southwestern Taiwan. The results reveal more then 64% and 76 % well samples of which NH_4-N contents are higher than the limit of second type groundwater pollution monitoring standard (0.25 mg/l) and drinking water quality standard (0.1 mg/l). Nevertheless, there are less 1 % and 5.4 % of well samples of which NO_3-N contents are higher than the limit of second type groundwater pollution monitoring standard (25 mg/l) and drinking water quality standard (10 mg/l). However, the nitrate contamination has been getting gradually worse on some agricultural region, especially in head recharge area of Alluvial fan. Mingchien area is one of these area located at Choshui alluvial fan due to the few mud layers in the geological profile, even the soil texture is clay under heavy rate of fertilization by local farmers. To prevent groundwater nitrate contamination, some strategies are recommended, such as fertilization of more times with less amount each application, application of foliar fertilization and control release fertilizer and amount control irrigation etc. However, the higher expense and labor will be needed if these strategies are applied. Farmer will not accept easily, unless the current crop was changed to economical crop to cultivate.

Keyword: Nitrogen, Nitrate, Ammonium, Groundwater.

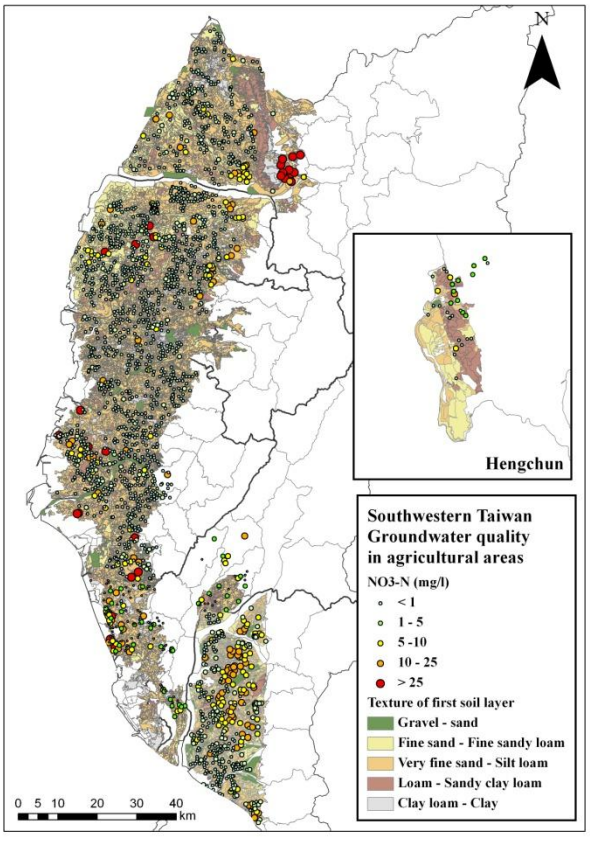

Fig. 1. Nitrate-nitrogen of groundwater distribution in agricultural regions in southwestern Taiwan

Environmental Forensics

NO.	Country	Title	Authors	Page
EF-O-1	Taiwan	Identifying the Source of Heavy Metals Contaminated in Farmlands and Cases Sharing	Huei-YA Lin*(林徽雅), Fun-Hsin Chou, Chi-Jui Lee, Pei-ShanCheng, Huei-Ju Fan, and Yu-Chieh Lin	78
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Identifying the Source of Heavy Metals Contaminated in Farmlands and Cases Sharing

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Extended abstract

Heavy-metal pollution of farmland soils is an serious concern environmental problems in Taiwan due to its potential public health risk. The prosecution and charge of soil heavy-metal pollution require environmental investigation for identifying the source of the pollution. Therefore, the purpose of this study is to develop a strategy to identify the source of heavy metals in a contaminated site. The consecutive steps of this proposed strategy are (1) to establish the spatial and temporal correlations of the polluted site with the potential sources of the pollutants, (2) to establish the source-sink relation by understanding the transport pathways of the pollutants and (3) to provide the essential information to the environmental protection agencies to conduct investigation for legal evidences. The proposed strategy was applied to identifying the sources of heavy-metal in the contaminated farmlands at Taichung. Combine with monitoring stations and geographic information system to establishing a conceptual model, which can collected data for describing the spatial distribution of the pollutants and to narrow down the area containing the potential sources of the pollutants. Subsequently, water quality was continuously monitored in selected area and the occurrences of abnormal water quality were recorded, which were then used to trace the source of the pollutants. The samples of the potential sources, transport pathways and polluted sites were collected and analyzed for elemental and isotopic compositions to find fingerprints to trace down the exact source of the pollution. The information can be then provided to the environmental protection agencies to implement on-site inspections and record reviews to obtain direct evidence of heavy metal discharge.

Keywords: Farmland soil pollution, suspicious pollution sources , heavy-metal

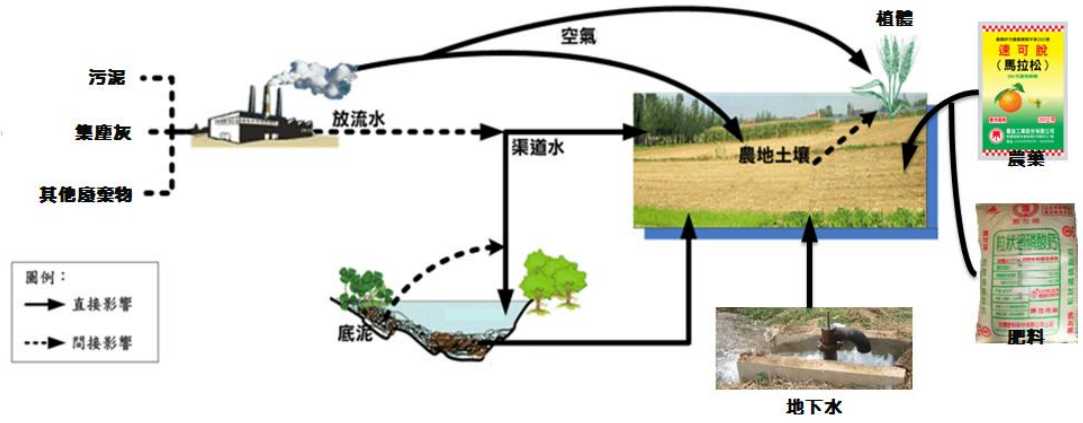

Figure 1. Heavy-metal in environmental media multiple transmission relations schematic

Application of Geographic Information System to Soil and Groundwater Contamination Management

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Extended abstract

To achieve the goal of environmental sustainability, Taiwan Environmental Protection Administration (Taiwan EPA) had adopted professional knowledge of environmental management combined with geographic information technology to develop rather perfect methods and tools for soil and groundwater contamination. Four information mechanisms had built to provide data-link solutions for contaminated land management. (1) Map data and soil & groundwater information were easily shared and integrated together through Info Exchange Platform across unit organizations. It can provided rapid, effective and meaningful information with a systematic approach and display it intuitively with a spatial method. (2) Information of Cloud Database effectively improved administrative efficiency, and also supported main GIS system to provide user spatial analysis. (3) Integrated with handheld devices, Geographic Information System (GIS) supported contamination survey operation for locating and provided more map data for field survey reference that allowed real-time return of on-site records and helped accuracy. Moreover, the portable device should be equipped with off-line operation mode. (4) Decision Support System of contaminated sites was provided, such as contaminated potential analysis & tracing mechanism of contamination source. This method had already applied to large-scale soil contamination and specific region by investigation with GIS at heavy metals in farmland (Farmland Soil Contamination Management System) and abandoned factories (Soil contamination Management System of Abandoned Factories).

Keywords: GIS, soil and groundwater management, mobile GIS technology, farmland contamination, abandoned factories

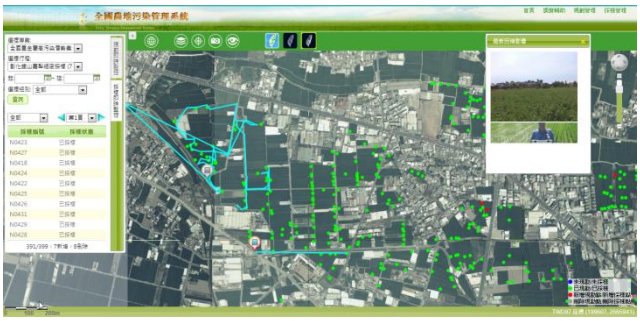

Figure 1. Real time access to field sampling information & personnel location from Farmland Soil Contamination Management System.

Figure 2. System Solution to Soil contamination Investigation for Abandoned Factories.

Remediation of Heavy Metals

Effects of Remediation Train Sequence on Decontamination of Heavy Metal-contaminated Soil Containing Mercury

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Extended abstract

When a contaminated site contains pollutants including both non-volatile metals and Hg, one single remediation technology may not satisfactorily remove all contaminants. Therefore in this study, chemical extraction and thermal treatment were combined as a remediation train to remove heavy metals, including Hg, from contaminated soil. A 0.2 M solution of EDTA was shown to be the most effective reagent for extraction of considerable amounts of Cu, Pb, and Zn (> 50%). Hg removal was ineffective using 0.2 M EDTA, but thermogravimetric analysis suggested that heating to 550 °C with a heating rate of 5 °C/min for a duration of 1 hr appeared to be an effective approach for Hg removal. With the employment of thermal treatment, up to 99% of Hg could be removed. However, executing thermal treatment prior to chemical extraction reduced the effectiveness of the subsequent EDTA extraction because non-volatile heavy metals were immobilized in soil aggregates after the 550 °C treatment. The remediation train combining chemical extraction followed by thermal treatment appears to remediate soils that have been contaminated by many non-volatile heavy metals and Hg.

Keywords: Heavy metal; soil contamination; heat treatment; chemical extraction.

Arsenic release into soil solution and accumulation by paddy rice grown in As-contaminated soils as affected by organic matter application

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Extended abstract

The increase of As uptake into rice (*Oryza sativa* L.) plants has become a potential dietary risk to human health. This study investigates the effects of application of three kinds of organic matter on the As release in soil solutions and accumulation in paddy rice grown in As-contaminated soils. Two As-spiked soils (Pc and Cf) and a geogenically As-contaminated soil (Gd) collected from Taiwan were used. The soils were amended with, 0% (control), 1%, and 4% organic matters [soybean meal (SB), cattle-dung compost (CD), and sugarcane dregs compost (SC)] respectively. The results of soil flooding incubation study indicated that organic matter applications enhanced the release of As into soil solutions, and the extent of enhancement was higher in the SB (easily decomposable organic matter) treatments than CD and SC treatments, due to the concentrations of dissolve organic carbon in soil solutions were higher in the SB application. The accumulation of As in rice plants was enhanced by organic matter amendments compared with control treatments, and the SB treatments had the higher As accumulation due to the higher As concentrations in soil solutions. This effect of application of organic matter on As release into soil solutions could be more notable in soils with high pH and low As sorption capacity (such as Cf soil), thus resulting in the increase of As toxicity to rice plants. Therefore, it is important to evaluate the properties of organic matters and soils carefully before adding organic materials into As-contaminated soils.

Keywords: Arsenic, organic matter, paddy rice, soil amendment

Water Management to Reduce the Arsenic Content of Brown Rice for Different As-Contaminated Soils

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Extended abstract

Methods of soil water management have been developed to mitigate the arsenic (As) phyto-toxicity of paddy rice and the As content of brown rice. However, little attention focused on the soil fundamental characteristics and the process of water removal among soils. The study aimed to (1) analyzes the predominant factor in the soil water management that contributed to diminish arsenic in the brown rice; (2) exploits the feasible soil water management that successfully mitigated the arsenic content and arsenic speciation in the brown rice, which grown on arsenic contaminated soil.

Two parts of experiments were executed (Figure. 1). Arsenic spiked to soils was to stimulated levels of arsenic contamination. The soil, for example Pc, spiked with 20 mg As/kg was denoted as Pc+20. Several soil water managements were obtained, the management that the aerobic treatment takes place before the rice heading and followed by flooding treatment was denoted as (-/+); on the opposite, written as (+/-). Convention management employ a week of aerobic treatment before heading period, while the saturated management maintains soil porosity saturated by water during the rice growing period. Also, two treatments of water removal techniques were tested, merely through evapo- transpiration and with the addition of drainage were discussed in the study. Selected soils with varied characteristics were used as study material. Some crucial properties of the soils were listed as Table 1.

In PART 1 EXP., the soil water management treatment (-/+) and (-/-) significantly decreased the arsenic content of brown rice to 0.2-0.4 mg/kg, while the As content of brown rice were 0.5-0.9 mg/kg in the (+/+) and (+/-) treatments of Lk soils. Drainage before heading kept the arsenic in non-labile for aerobic soil to avoid the uptake of arsenic in the soil pore-water. On the contrary, merely evapo-transpiration was unable to remove water and create soil aerobic condition in Er soil, thus, failed to decrease arsenic concentration in the brown rice. In PART 2 EXP., the convention treatment diminished the arsenic content in the Gd soils to the level of 0.4 mg/kg, while arsenic content in the Er soils didn't significantly eliminated. Either increased the duration of aerobic soil before the heading period or maintained water saturated status was recognized as proper ways to mitigate the situation.

Keywords: Arsenic (As), water management, soil aerobic treatment, rice (*Oryza sativa* L.)

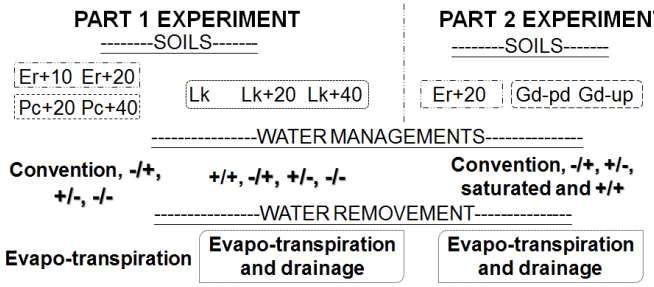

Figure 1. The framework of the study. PART 1 EXPERIMENT elucidated the water removal method is critical to the effect of soil water managements. Additional water management in PART 2 EXPERIMENT was tested for reducing arsenic in brown rice.

Table 1. Physical and chemical properties of studied soils.(mean ± std)

Soil	pH	Texture	Organic carbon (%)	amor./free Fe (g/kg)	Soil arsenic (mg/kg)
Er soil	7.7	Loam	1.3	4.0/8.4	8.1
Pc soil	6.4	Clay	1.1	5.1/43	10.8
Lk soil	5.1	Silty clay	-	- /23	10.9
Gd-pd soil	5.8	Silty clay	3.6	18±1/27±1	379
Gd-up soil	5.7	Silty clay	2.0	15.8/45±3	531±32

The Improvement of Phytomediation on the Treatment Effectiveness of Heavy Metals with Energy Sunflower Plants with Calcium Peroxide and Phytohormones

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Extended Abstract

Phytomediation is an environmentally friendly green rehabilitation technology that is often incorporated with an application to improve calcium peroxide and phytohormones required for the growth of agricultural plants with the expectation to improve the effectiveness of plant rehabilitation. This study mainly consists of two parts: (1) water culture experiment and (2) pot culture experiment. In the water culture experiment, we attempt to understand the influence of the addition of calcium peroxide, phytohormones (IAA and GA3) and a chelating agent on the growth of sunflower plants. From the growth, we are then able to know the effectiveness of the addition of phytohormones. However, in the pot culture experiment, when hormones and the chelating agent EDTA are introduced to different plant groups at the same time, if the nutrition in the water required by plants is not available, the addition of the hormone cannot negate the toxicity caused by EDTA. In terms of calcium peroxide, due to quick release of oxygen in water, this study fails to apply calcium peroxide to the water culture experiment.

When the pot culture experiment is used to examine the influence of hormones at different concentration levels on the growth of sunflowers, GA3 10-8M is reported to have the optimal effectiveness, followed by IAA 10-8M; IAA 10-12M has the lowest effectiveness. According to an accumulation analysis of heavy metals at different levels, GA3 concentrates in leaves to transport nutrition in soil to leaves. This results in an excellent TF value of 2.329 of GA3 than 1.845 of the control group indicating that the addition of the hormone and chelating agent to GA3 increases the TF value and the chelating agent is beneficial to the sunflower plant. If we examine phytoextraction ability, the one-month experiment was divided into three stages for ten days each. The concentration level of heavy metals in the soil at each stage dropped continuously while that of the control group decreased from 31.63 mg/kg to 23.96 mg/kg, GA3 from 32.09 mg/kg to 23.04 mg/kg and EDTA from 30.65 mg/kg to 25.93 mg/kg indicating the quickest growth period of the sunflowers from the formation of the bud to blossom. During the stage, the quick upward transportation of nutrition results in quick accumulation of heavy metals; the accumulated speed of heavy metals is found higher than that of directly planted plants. This study shows an improvement in the effectiveness of the addition of hormones on plant extraction and when rehabilitation is incorporated with sunflowers with the beginning bud formation, better treatment effectiveness can be reached.

Keywords: phytomediation, heavy metal, chelating agent EDTA, energy plant (sunflower), hormones (IAA、GA3), phytoattenuation

Table1, three groups of explants BCF, TF values

Factors	Treatment	Value
BCF	Control	0.833
	GA_3	0.744
	IAA	0.721
TF	Control	1.845
	GA_3	2.329
	IAA	1.829

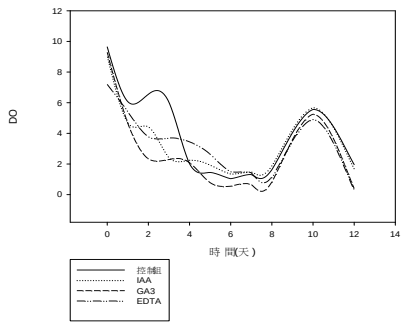

Figure1. hydroponics experiment 1 DO change daily in each group

The effects of adding husk on arsenic concentration of brown rice grown in two poor-drained arsenic-contaminated soils

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Extended abstract

Arsenic (As) is a metalloid carcinogen. Because arsenite (As^{III}) is predominant in a anaerobic environment and has higher mobility and biotoxicity, rice grown in paddy fields is more efficient in accumulating As in plant tissue than other cereal grown in dry farmlands. Related researches have shown that appropriate drainage for rice cultivation could alternate arsenic redox state and consequently inhibit As uptake and accumulation in rice. Rice husk, as a green waste, is less decomposable and more consistent in shape and structure which can improve soil structure, increase soil porosity and enhance soil drainage for fine-textured or clayey soils. Accordingly, husk is assumed to enhance the efficiency of drainage management in reducing As uptake by rice. Therefore, this study is to evaluate the effects of husk addition on As accumulation in brown rice in two As-spiked poor-drained soils. The Er loam soil and Hh silty clay loam soil were collected and were spiked with As at 0 and 15 mg kg^{-1} soil. Rice was cultivated in the four soils with throughout flooding to 3-5 cm above soil surface (Flooding treatment) or with drainage at the maximum tillering stage (40 day after transportation; DAT) for 10 days (Drainage treatment) while husk was adding at the rates of 0 and 2.5% with basal fertilizers two days before transportation. The results show that, as expected, drainage management increased the soil Eh, decreased As concentrations in soil solutions and consequently inhibited As accumulation in rice tissues. As an observational result, drainage was actually accelerated by the husk addition. However, the As concentration in soil solutions largely increased after husk addition which was resulted by the more reducing condition (lower soil Eh). This effect was contributed mainly by the decomposition of the readily decomposable fraction of rice husk, despite the fraction is generally low. Consequently, the As accumulation in brown rice was increased by husk addition and could reach to a high level of 4.5 mg kg^{-1} which can be hazardous to the food chain (Fig. 1). Moreover, As phytotoxicity to rice was aggravated by husk addition in the As-spiked soils. Arsenite concentration in brown rice was in the range of 0.15-0.26 mg kg^{-1} which was not significantly affected by drainage management or husk addition. In comparison, dimethylarsenic acid (DMA) concentration increased with increasing total As concentration in brown rice as affected by drainage and husk treatments which indicates that excess arsenic in brown rice was accumulated mainly in the DMA phase. In this research, the overall effect of husk addition increased As accumulation in brown rice which implies that application of organic materials into As-contaminated soils needs to be carefully evaluated, even for the husk which content a low level of readily decomposable fraction.

Keywords: Arsenic (As); Drainage; Husk; Paddy rice, accumulation

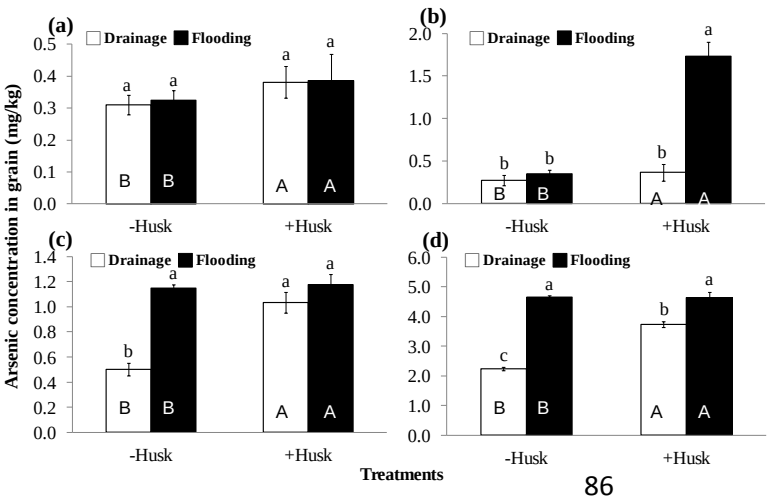

Fig. 1. The As concentration in brown rice grown in (a) Er soil, (b) As-spiked Er soil, (c) Hh soil, and (d) As-spiked Hh soil as affected by drainage management and husk addition. Different letters in lowercase and in capital indicate that there is significant difference between water treatments and between husk treatments, respectively (p<0.05).

An Online Monitoring System using Sulfur Oxidizing Bacteria for Detection of Toxic Chemicals in Stream Water

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Extended abstract

Release of toxic substances on river damage the aquatic environment and the population depend on it. Therefore, it is mandatory to prevent water resources from being polluted. Generally, physicochemical methods are used for monitoring the water quality. Though physicochemical methods are highly sensitive, these methods do not provide the biological information pertaining to the toxicity. Thus, in recent years real time biomonitoring has become the most effective and reliable method to obtain biological information relating to toxic events in an aquatic system, since it incorporates living organisms into the system to serve as biosensor. In the present study we investigated the on line water quality using sulfur-oxidizing bacteria (SOB) in Bukhan river, Gangwondo, South Korea. The toxicity monitoring system consisted of three SOB bioreactors (R1: continuous mode, R2 and R3: semi-continuous mode) and operated for more than 6 months fed with real stream water. Swine wastewater, nitrite (NO_2^-) and hexavalent chromium (Cr^{6+}) were used as the toxicant. 50 times diluted swine wastewater was added to the influent of the bioreactors. We found that 50 times diluted swine wastewater was very toxic to the SOB bioreactors in both continuous and semi-continuous mode, showing 90% inhibition of SOB activity within 1 h of operation. Addition of Cr^{6+} and NO_2^--N to the bioreactors also resulted 90% inhibition of SOB. This system is aimed toward providing a real time monitoring of water quality and tools for early warning toxicity assessment of emergency pollution levels. Thus, our toxicity monitoring system is useful for the optimal placement of on-line monitoring stations and the real-time management of data.

Keywords: Electrical Conductivity, Sulfur Oxidizing Bacteria, Sulfur Particles, Toxic Substance

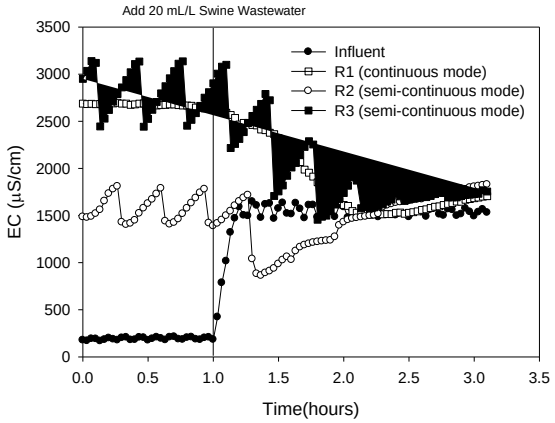

Figure 1. EC changes by adding 20 mL/L swine wastewater

Remediation of an Actual Mercury-Contaminated Soil Using the Iodide-Assisted Electrokinetic Process

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Extended abstract

The objective of this lab-scale study was to evaluate the feasibility of *in situ* remediation of subsurface mercury contamination using the iodide-assisted electrokinetic process. Due to negligence, beginning 1994 a building complex was built on a mercury-contaminated site in Taiwan before the regulatory authority noticed the problem of soil and groundwater contamination thereat. To resolve this problem, the potassium iodide-assisted electrokinetic (KI-assisted EK) process was proposed in this research. In this work an EK remediation system, including a gas-tight sand-box reactor with monitoring wells & caps, DC power supply, and electrodes of various materials, was first installed. Then an actual Hg-contaminated soil (Hg concentration of 3,000 to 5,000 mg/kg) was collected, characterized, and filled in the soil compartment of sand-box reactor simulating the unsaturated zone and saturated zone in the subsurface. In addition, 0.1 M KI lixiviant and/or actual groundwater were used as anolyte, catholyte and soil pore water. At this stage, an electric field was applied to the EK remediation system using a constant voltage mode (i.e., 1 V/cm) or constant current mode (i.e., 20 mA) for eight tests with different remediation time ranging from 1 to 14 days. The following are the research findings obtained using the KI-assisted EK process in this work: (1) migration of HgI_4^{2-} (originated from chemical reaction of Hg and KI in aqueous solution) toward the anode is the primary mechanism for Hg removal, whereas the transport of dissolved Hg_2I_2 toward the cathode end by electroosmotic flow is considered the secondary removal mechanism for Hg; (2) based on the mass balance of total Hg in the sand-box reactor, there might exist a mechanism relevant to Hg stabilization rendering the formation of unknown residual metallic Hg compound that is non-dissolvable by aqua regia digestion and for subsequent chemical analysis; (3) the emission of Hg vapor would not take place in the KI-assisted EK process; and (4) the KI-assisted EK process is considered to be technically and economically feasible as compared with other Hg remediation technologies. However, further studies are needed before the KI-assisted EK process could be implemented in the real world.

Keywords: Potassium iodide-assisted electrokinetic process; *In situ* remediation; Subsurface mercury contamination

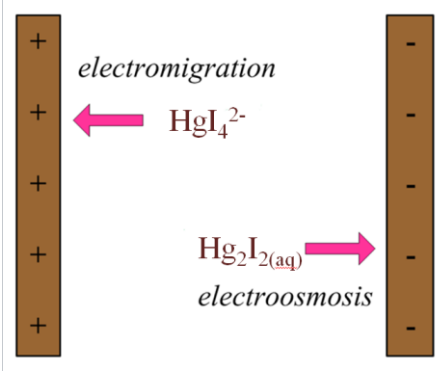

Figure 1. Schematic diagram showing two major removal mechanisms employed in electrokinetic remediation of mercury-contaminated soils using iodide lixiviant

Arsenic distribution in groundwater in southwestern Taiwan and evaluation of removal methods

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Extended abstract

Groundwater is one of water resource for agricultural irrigation in Taiwan. However, the arsenic (As) content is higher than 0.05 mg/L of irrigation water criteria in some locations, especially southwestern Taiwan. The As pollutant have accumulated in farmland and may cause human health risk. The study aim is to find out a better removal method to diminish As concentration in groundwater before irrigation. The lab-scale tests attempted to distinguish from several methods such as iron coagulation, ion-exchange, electro-coagulation, and absorption (active carbon); therefore, some removal tests based on the lab data were conducted with 2 Mg volume groundwater at field experiments. The results reveal that the iron coagulation has highest efficiency to remove out As among various methods in field studies. Moreover, Ferric chloride is not a prerequisite to reduce the As concentration, owing to the much higher Fe content in groundwater around southwestern Taiwan. The Fe^{2+} and As^{3+} are oxidized into Fe^{3+} and As^{5+} and form the precipitated compound after pumping. The As can be removed 50% at upper layer of 2 Mg groundwater after 3 days, and the As concentration can be lower than 0.05 mg/L after filtering. Nonetheless, the large storage facilities are need for conventional irrigation.

Keywords: Arsenic removal, groundwater, iron coagulation, irrigation

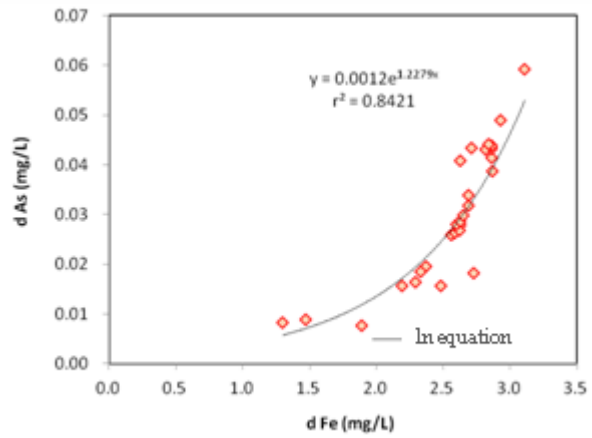

Figure1. The natural logarithm relationship of Ferric-Arsenic removal

Effect of soil As concentrations and genotypes on As content and speciation in grains of rice grown in As-elevated paddy soils

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Extended abstract

Rice consumption is a major route of As exposure to human for the population of worldwide. This study investigates the effect of rice genotypes and soil As concentrations on the content and speciation of As in rice grains grown in different levels of As-elevated paddy soils from Guandu Plain of northern Taiwan. Three levels of As-elevated soils (16.3 (As-L), 343.3 (As-M) and 512.3 (As-H) mg As kg^{-1}) and six rice genotypes commonly planted in Taiwan were used in this study. The concentrations of As (As species) in grains (bran and polished grain) were determined by high-pressure liquid chromatography-inductively coupled plasma mass spectrometry (HPLC-ICP-MS). The results indicate the As concentrations in rice grains were significantly lower in As-M and As-H soils compared with As-L soils, due to the As phytotoxicity occurring in As-M and As-H soils, as also indicating by the decrease of root length, shoot height, grain yields of rice grown in these two soils. The concentrations of As in rice grains of indica genotypes were higher than japonica genotypes grown in As-L soils, but no significant difference between indica and japonica in As-M and As-H soils. The results indicate that As content in grains of rice grown in As-elevated paddy soils is not proportional to soil As concentrations and japonica genotypes are recommended for planting in As-contaminated soils. The predominant As species found in rice grains were dimethylarsinic acid (DMA) and the concentrations and percentage of DMA increased with total As concentrations, whereas the arsenite remained at the narrow range from 0.1 to 0.3 mg kg^{-1}. Because of the lower toxicity of DMA than inorganic As species, it suggests that the health risk may not be increased through consumption of rice as total As content in grains is increased.

Keywords: Arsenic, arsenic species, rice, genotypes, phytotoxicity, paddy soil

Bioremediation

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Aerobic Biodegradation of Dichloroethene in Simulated Groundwaters

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Extended abstract

The objective of this study was to explore the growth and degradation capability of an aerobic mixed culture to degrade DCE. In microcosm study, DCE removal efficiency of the two indigenous microorganisms reactors with and without the addation of H_2O_2 was 60% and 40%, respectively. DCE removal efficiency of the two bioaugmeanted reactors with and without the addation of H_2O_2 could reach to 90%. In addition, biodegradation of DCE followed the first-order mechanism (R^2 = 0.91~0.98) and the rate constant of biodegradation (K_{DCE}) was in the range of 0.07 ~3.89 day^{-1}(Figure1 and Table1)). In the DCE-acclimated culture, *Polaromonas* sp. JS666 and *Comamonadaceae* OTSz_A_293 were identified.

Keywords: Dichloroethylene, biodegradation, biostimulation, bioaugmentation

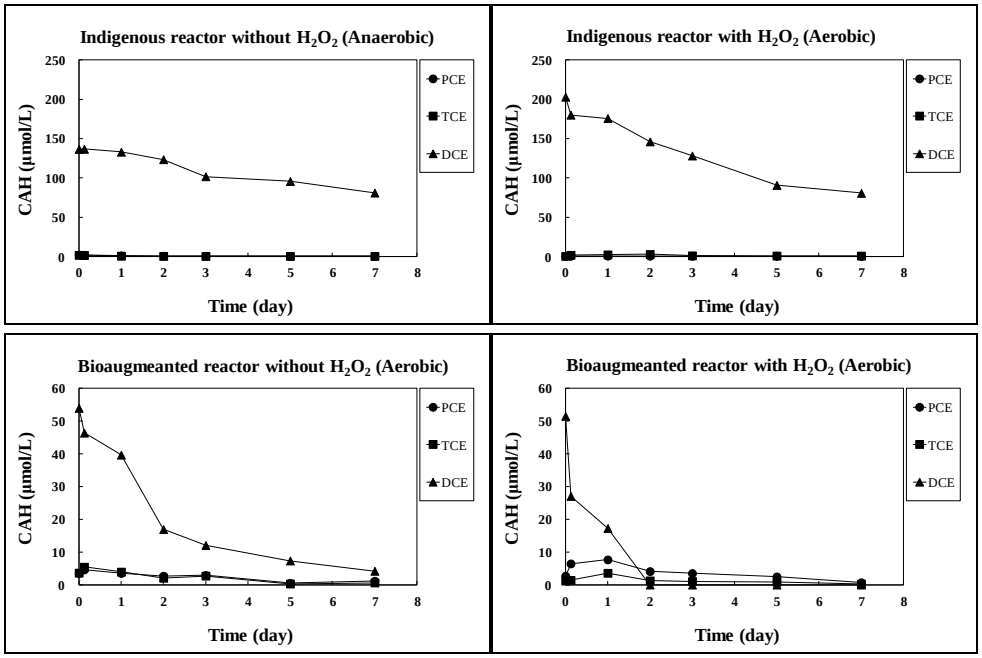

Figure 1. Biodegradation rates of different methods on batch simulation tests

Table 1. The kinetics of biodegradation of DCE on batch simulation tests

	Indigenous reactor without H_2O_2	Indigenous reactor with H_2O_2	Bioaugmeanted reactor with H_2O_2	Bioaugmeanted reactor without H_2O_2
Zero-order ($\mu mol\ L^{-1}\ day^{-1}$)	8.39 (R^2 = 0.95)	17.90 (R^2 = 0.85)	24.31 (R^2 = 0.86)	47.18 (R^2 = 0.80)
First-order (day^{-1})	0.07 (R^2 = 0.96)	0.15 (R^2 = 0.91)	0.94 (R^2 = 0.95)	3.89 (R^2 = 0.98)

Biological Chlorobenzene Remediation

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Extended abstract

The location in Basel, Switzerland was used since 1859 by different companies for the production of various chemical products. The area around the building 305-353 the groundwater is contaminated with Chlorbenzene and degradation products (total over 164,100µg/l). The current user of the location operates for a couple of years a free phase pump to reduce the Chlorbenzene in the groundwater. Due of poor results the BioSoil was requested to remove Chlorbenzene from the groundwater.
After removal of all free phase, the remediation is preformed in two steps, the first step will be an anaerobic step for the degradation of Trichlorbenzene to Dichlorbenzene. The second step will be preformed under aerobic conditions, the degradation from Dichlorbenzene to Monochlorbenzene to CO_2 and water. The pilot test were done in the summer of 2011 and showed promising degradation rats. During the test Percol was added to present nutrient of bacteria´s. Percol is a natural product which exclusively produced for BioSoil only. Percol stimulate the growth of bacteria which is needed for the anaerobic and also for the aerobic degradation. In the second step, further downstream in order to the groundwater velocity, the aerobic degradation was forced by adding H_2O_2. In the "fullscale" approach, peroxide is replaced by compressed fresh air. Free phase chlorinated Benzene is still detected. Free phase will be skimmed of and filtered out by using a hydro cyclone and a bioreactor. In other wells Chlorinated Benzenes were detected in high concentrations, in droplets in the groundwater. The chlorinated benzenes are to be degraded only by specific infiltration of nutrients and compressed air.

The result shows in the aerobic area:

- The total anaerobic condition in the ground water could be change to a permant arobic condition.
- In case of a highly groundwater velocity it became hard to keep the arobic condition in the downstream in case of the limiting oxygen the aerobic activities are very low.

In anaerobic area:

- The groundwater milieu was in the start up phase already under anaerobic condition, and the biological process was forced with the injection of Percol.

Keywords: Chlorobenzene, Percol, biological remediation

Biospeed Concept to Shorten Remediation Time for Chlorinated Ethenes

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Extended abstract

BioSoil has developed a technique to shorten the lag phase often observed during the anaerobic bioremediation of chlorinated ethenes and to shorten the total remedation time itself substantially. The concept is a combination of establishing a pool of dechlorinating microorganisms as soon as possible by starting on a small scale (with a "quick start unit") and by stimulating microbial processes by means of heating.

For the quick start unit (10-feet container) no or less permits are required and it can be started when demolition and or excavation are still taking place prior to the bioremediation. Also crucial information like well spacing, permeability data are gained during this early stage, that can be used for further optimizing the full-scale remediation.

At a site contaminated with tetrachloroethene (PCE) and trichloroethene (TCE) no signs of complete reductive dechlorination were present before the remediation started. The prevailing redox conditions were aerobic to nitrate reducing and no cis-1,2-dichloroethene (CIS), vinyl chloride (VC) or ethene was detected. Also no Dehalococcoides cells were detected at the site (below detection limit). However, the targets for remediation (sum chlorinated ethenes = 1,000 µg/l) should be achieved within 2 years.

BioSoil started with a small scale system in the source area, consisting of two extraction filters and 8 infiltration filters and continuous circulation of ground water together with the addition of an electron donor. The total volume of this "in situ bioreactor" was about 200 m^3. The circulated groundwater was heated up to ±25℃ to increase the rate of microbial reduction of competing electron acceptors like oxygen and nitrate and therefore establishing optimal redox conditions as fast as possible and increasing the rate of reductive dechlorination itself.

Already within a month PCE concentrations up to 25,000 µg/l were fully degraded to below detection limit and CIS concentrations increased up to 140,000 µg/l. For about two months no further dechlorination of CIS was observed and no Dehalococcoides cells were detected either. It was therefore decided to inoculate the test area with Dehalococcoides rich ground water from an ongoing successful remediation. Within two weeks after inoculation VC was detected and after three weeks the number of Dehalococcoides cells increased from below detection limit to 1.3x109 cells/l and ethene was detected. Meanwhile BioSoil had started with groundwater circulation and electron donor dosage in the full-scale area. After the required redox conditions were achieved, water from the "quick start" area was used as inoculum for the full-scale area. After about 1 year, only 4 out of 15 monitoring wells are still exceeding the limit, of which 3 are in the range between 1,000 and 3,000 µg/l (sum). These results demonstrate the potential of the biospeed concept to reduce the lag-phase significantly and therefore the total remediation time.

Keywords: Chlorinated ethenes, Dehalococcoides, biospeed

Biodegradation of 4-monobrominated diphenyl ether with anaerobic microcosms

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Extended abstract

Polybrominated diphenyl ethers (PBDEs) are among the most commonly used brominated flame retardants (BFRs) which have been widely used in many plastic and electronic products for several decades. Recently, these compounds have caught serious concern for public safety because of their ubiquitous distribution in the environment, toxicities, and persistency in degradation. Four congeners of PBDEs were already listed on the table of persistent organic pollutants. Therefore, PBDEs constituted one of the main targets in environmental remediation. In this study, we investigated the microbial degradation of 4-monobrominated diphenyl ether (BDE-3) with two anaerobic sludges, as well as the effect of carbon sources on the degradation efficiencies. During the degradation process, the by-products, diphenyl ether and bromide ion, were detected. This indicated that the microorganisms transformed the pollutant through the debromination reaction. We found the addition of glucose facilitated the BDE-3 biodegradation amount and the biodegradation efficiency in the Jhongsing sludge. However, the H_2 gas generation did not increase as in the Li-Ming sludge. The composition of the microbial community was analyzed through the pattern of amplified 16S rRNA gene fragments in denatured gradient gel electrophoresis. Different band patterns revealed the persistence, extinction, or evolvement of specific microorganisms during the biodegradation process. The community structures changed with the addition of BDE-3 and the glucose. The fragments enriched in BDE-3-degrading anaerobic sludge samples are *Clostridium* sp., consistent with the H_2 gas generation and the facilitation of debromination. Our findings provided an insight into the biodegradation of PBDEs and can facilitate the bioremediation of BFRs in the environment.

Keywords: 4-Monobrominated diphenyl ether; Anaerobic Sludge; Debromination; Glucose; Denaturing Gradient Gel Electrophoresis

PeroxyChem's Chemical and Biological Remediation Technologies and Applications at Challenging Sites in China

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Extended abstract

Environmental remediation, especially brownfield remediation has been emerging in China for several years. Some of the advanced remediation technologies of PeroxyChem Environmental Solutions, such as Klozur® *in situ* chemical oxidation (ISCO), EHC® *in situ* chemical reduction (ISCR), and heavy metal stabilization, etc., have been introduced to China and adjusted to better meet the needs of the Chinese remediation projects, which typically got a short timeframe.

The largest ISCO project in China so far is ongoing using Klozur® activated persulfate technology. This brownfield site is a former chemical plant, with key contaminants of concern (COC) as *o*-(*p*-) nitrochlorobenzene (NCB) and chlorobenzene. A pilot study was successfully accomplished at this site in 2013. The pilot study area was 200 m^2, down to 10 m below ground surface, with a total volume of 2,000 m^3 in the target treatment zone. Selection of Klozur® activated persulfate technology is due to its overall advantages over Fenton's chemistry and permanganate oxidant. Injection through injection wells and direct push technology were used for delivering Klozur® oxidant solution into the deep zone (i.e., 4.5-10 m bgs), while *in situ* soil mixing was used in shallow zone (i.e., 0-4.5 m bgs). By the end of the 4-month pilot study, *o*-(*p*-) NCB degraded significantly and met the remedial goal in most of the sampling points, while all the other COCs met RG completely.

PeroxyChem's EHC® ISCR technology actually exerts synergistic effect of chemical reduction and anaerobic bioremediation. EHC® demonstrated terrific performance in a pilot study at a brownfield site highly contaminated by chlorinated VOCs (CVOCs). With just 0.5% w/w dosage of EHC®, 1,2-DCA concentration dropped from over 3 g/L to < 1 mg/L (Fig. 1), significant removal of 1,1-DCA and chloroform was also achieved. Full scale implementation of *in situ* groundwater remediation using EHC® for a plume over 50k m^2 at this site is expected to launch in 2015. Another *in situ* groundwater remediation project by EHC® is ongoing at an active industrial site. Significant removal (3-4 orders of magnitude reduction) of the two COCs, i.e., 1,1,1-TCA and 1,1-DCA, was achieved at Area #1 in 3 months after EHC® injection and no rebound in the next two quarterly monitoring events. Remediation of all areas at the site by EHC® is expected to finish by 2016.

Heavy metal contamination at industrial, mining, and arable lands is a severe issue in China. PeroxyChem's EHC-M® and Daramend®, and newly launched MetaFix™ series heavy metal stabilization products differentiate from the competitive products by sound working mechanisms and demonstrated long term stability. Three orders of magnitude of reduction of leaching concentrations of As, Cr(VI), etc. can be readily achievable.

Keywords: Remediation in China, ISCO, ISCR, heavy metal stabilization

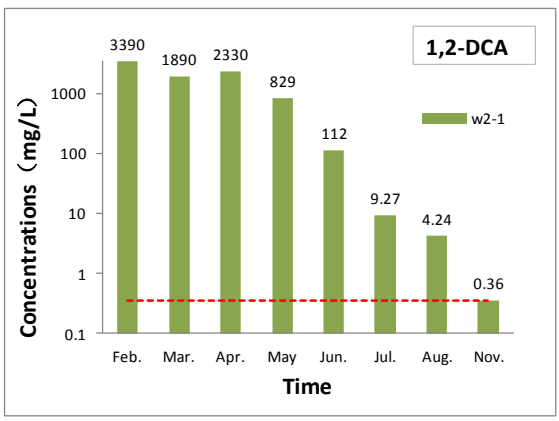

Fig. 1 Significant removal of 1,2-DCA in groundwater following implementation of 0.5% w/w EHC®

Application of Compost Tea for the Treatment of Diesel Contamination by Soil Washing

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Extended abstract

Although soil washing has been successful in the past decades, applications of chemical surfactants were criticized with the concerns of secondary pollutions in the environment. In this research, efforts have focused on finding environmental friendly bio-surfactants to replace chemical surfactants. Mature compost made from food waste composting process is known to contain abundant humic substances (HS). Humic substances are water soluble and know to exhibit surfactant properties which can result in micelle effects. Therefore compost tea made from mature food waste compost should be rich in humic substances and should have potential to replace chemical surfactant in soil washing applications. This research is aimed at using compost tea to soil washing for diesel contaminated soil. In a simulated diesel contaminated fine sand example, by using compost tea with 1300 mg/L humic concentration, 60% of removal efficiency (RE) can be achieved while only 40% RE for that of using water. When comparing compost tea versus commercial surfactants, the washing RE for compost tea was 62.54%; and was 60.79%, 56.65%, and 58.18% for that of Triton, SDS and APG. When the experiments were repeated using silt and clay (< 0.05 mm) soil as a probe, the RE dropped to 23.79% for compost tea, and to 17.77% for that of water. To improve the washing efficiency for the diesel contaminated clay soil, the washing time was extended to 48 hours, and 39.42% RE was achieved by using compost tea as the washing fluids. Our preliminary results have indicated (1) compost tea is an effective washing fluid in both diesel contaminated fine sand and clay soil matrix; (2) compost tea is as effective as or better than the commercial surfactants tested; (3) when dealing with diesel contaminated clay soil, an extended washing time is required with adequate mixing operation. Finally, it is worth to mention that compost tea is also a liquid fertilizer with natural organic humic substances and abundant in nutrients. If the proposed compost tea can eventually replace chemical surfactants in diesel contaminated soil washing, a green and sustainable remediation technology can be expected.

Keywords: soil washing, compost tea, food waste recycling, bio-surfactant, green remediation.

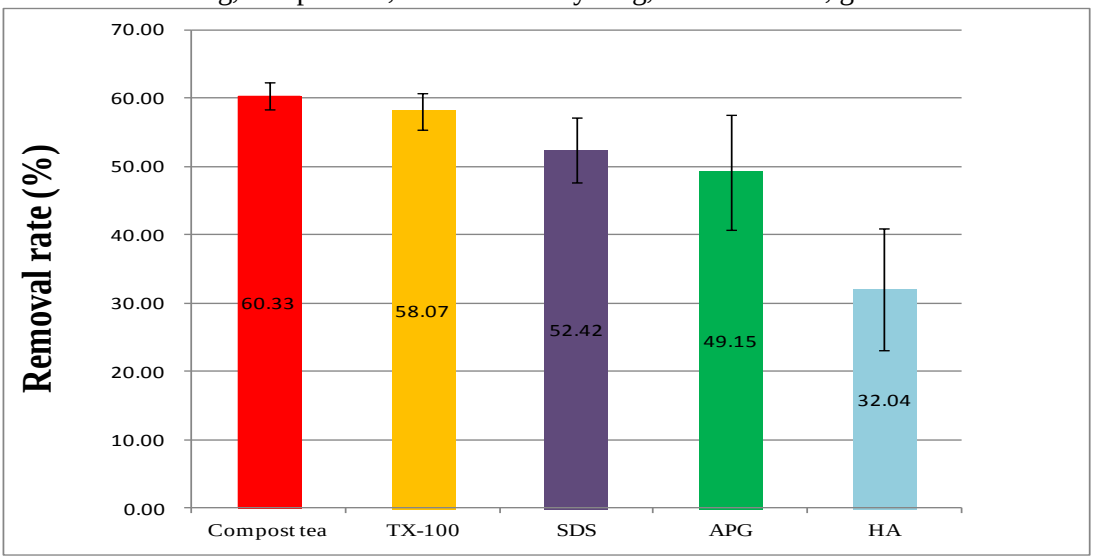

Figure. Removal Efficiency of compost tea compared with commercially available surfactants.

Poster Session

Sustainable Remediation

NO.	Country	Title	Authors	Page
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Environmental Liability Insurance for Contaminated Site Management in Taiwan-Vision and Challenges to Policy Making

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Extended Abstract

The occurrence of contaminated sites has long been a great challenge to developing and developed countries. It is recognized as an inevitable legacy from the economic development path. Unfortunately, the remediation of the contaminated sites can pose stress not only on environment but also on financial status on the responsible parties and eventually to responsible governmental agency (*i.e.*, the Soil and Groundwater Pollution Remediation Fund). Over a decade, the Taiwan Environmental Protection Administration (TWEPA) has been in a position to understand and to discover the extent of contamination in a national scale. Thus, various comprehensive site investigation programs targeted different industrial sites have been carried out. However, strategies of more proactively preventing contamination and relief potential financial risks should be considered to establish a protective umbrella with respective to contaminated sites.

Based on the experience of developed countries, the environmental liability insurance (ELI) can be one of the feasible policy options. However, the policy making has been a great challenge and the domestic insurance market, such non-existence of ELI policy, also is a hurdle needed to be overcome. Therefore, TWEPA started to map out a framework of ELI for contaminated site management with the vision to facilitate site remediation and revitalization and to elevate the capability of environmental risk response and management of industry. The recent study has revealed that the regulatory support, stakeholders' acceptance, and incentive programs are the major challenges to such policy. For instance, the Environmental Liability Act drafted in 2003 has not been officially promulgated and the policy has to be limited to the regulatory delegation in the Soil and Groundwater Pollution Remediation Act (SAGPRA). Consequently, the framework can only integrates voluntary insurance instead of compulsory insurance. The realization of the benefit of the policy might take a longer time and questioning from stakeholders could be more than anticipated. On the other hand, an incentive program can be established within the SAGPRA that can facilitate the realization of ELI for contaminated site management.

Remediation of Organic Pollutants

The Application of SPME on the Bioavailability Assessment of PAH in Contaminated Soils

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Extended abstract

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous environmental contaminants arising from a variety of sources including fossil fuel combustion, oil spills and some industrial processes. PAHs have been suggested to be either probable or possible human carcinogens and have been identified as priority pollutants by the United States, the European Union as well as Taiwan. In the Netherlands, solid phase microextraction (SPME) has been proposed as the standard procedure for bioavailability assessment of organic contaminants in soils; representing the actual exposure concentrations by the bioavailable fractions. This study investigated the variations of bioavailability of benzene, naphthalene, phenanthrene and pyrene in soils with various textures, organic contents, and microbial inoculation conditions using SPME fibers coated with polydimethylsiloxane (PDMS).

Biodegradation assays showed that PAH degradation rates increased in soils consisted of more silt and clay, whereas both the degradation rates and amounts decreased with increasing soil organic contents. The PDMS-SPME measurements indicated that the bioavailable fractions were in proportion to the biodegraded fractions. For the 40 tested various soil samples, the relationship between the amounts degraded by microorganisms and the amounts estimated by the PDMS-SPME gave an excellent correlation coefficient (R^2) as 0.92 (Fig. 1). These results strongly suggested that the SPME method could be applied to determine the bioavailable fractions that represent the actual exposure concentrations of PAHs in contaminated soils.

Keywords: PAHs, bioavailability, solid phase microextraction (SPME)

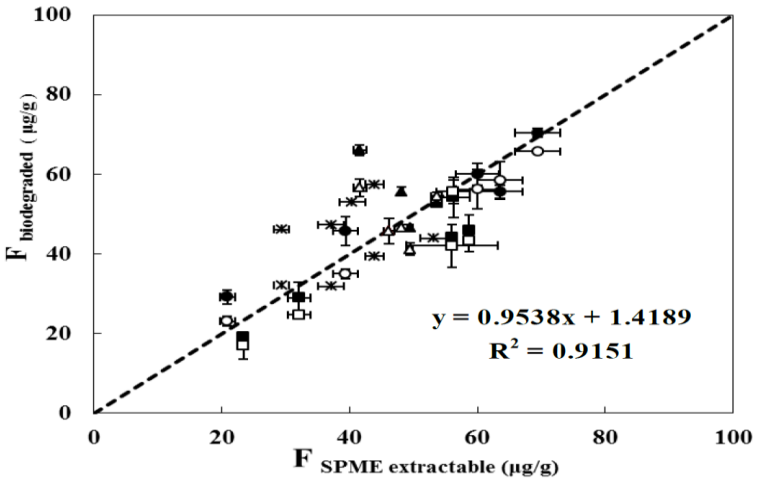

Fig. 1 The relationship between the biodegraded amounts and the SPME extracted.

Distribution and Degradation of Groundwater Contaminants at the RCA Taoyuan Plant

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Extended abstract

Radio Corporation of America (RCA) Taoyuan Plant is the first soil and groundwater pollution remediation site. The site was found to be polluted by chlorinated volatile organic compounds (VOCs) due to improper dumping or leakage of solvents. The major contaminants are tetrachloroethylene (PCE), trichloroethylene (TCE), 1, 1, 1- trichloroethane (1, 1, 1-TCA) and their degradation byproducts. These VOCs are dense non-aqueous phase liquids which can hardly dissolve in groundwater, and thus become the source of long-term contamination. Because groundwater flows northward horizontally, contamination was found primarily in the northwest side and north side of the plant. Site investigation indicated that the upper aquifer is a thick gravel layer, and the deep aquifer is composed of sand interbedded with mud layers. Enhanced reductive dechlorination (ERD) method has been adopted to clean up contaminants in the groundwater since 2005. By injecting reducing agents, the aquifer condition became favorable to anaerobic biodegradation. The concentration of PCE and TCE in the groundwater reduced significantly seven years later. However, the concentration of vinyl chloride (VC), a highly toxic compound as resulting from biodegradation processes, exceeded the regulatory standard at many wells. The result may be caused by the biochemical properties and degradation environments of PCE and VC. Therefore, an effective solution for the cleanup of VC contamination should be considered in the future.

Keywords: groundwater pollution, RCA, DNAPLs, remediation

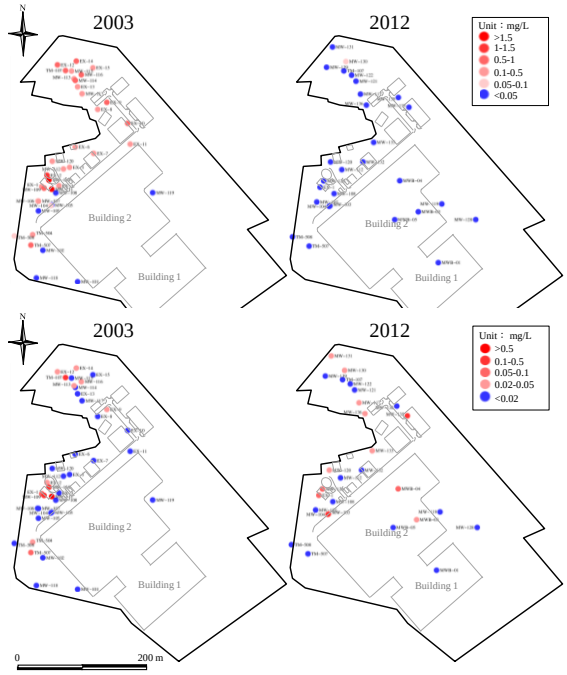

Figure 1. Distribution of PCE concentration is in the groundwater at the Taoyuan plant. High concentration was found in the north and northwest side of the site in 2003. After remediation, PCE concentration exceeding the remediation standard was found only at 1 monitoring well, MW-130, in 2012.

Figure 2. Distribution of VC concentration is in the groundwater at the Taoyuan plant. The VC concentration in 33% groundwater samples exceeded the regulatory standard (0.02 mg/L) in 2003. In 2012 about 50% groundwater samples exceeded the standard.

Sorption and Desorption of Explosives in Soils and Sediments

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Extended Abstract

Fate and transport of explosives in the subsurface environment will be affected by sorption and desorption mechanisms in the contaminated sites. Four target compounds include 2,4-dinitrotoluene (2,4-DNT), 2,4,6-Trinitrotoluene (TNT), cyclotrimethylene-trinitramine (RDX) and cyclotetramethylene-tetranitramine (HMX) will need in this study. This study used soils and sediments with different organic carbon content to assess the effect of sorption-desorption mechanisms of explosives. Three levels of organic carbon content were adopted in this study (organic carbon content below 2%, 2-5%, and more than 10%). The equilibration time of sorption-desorption study was evaluated by batch experiments. Column experiments were utilized to evaluate the leaching potential of explosive-contaminated soils. Moment analysis was used to estimate mass transfer into aqueous phase in explosive-contaminated soils.

Keywords: Explosives, Sorption, Soils and Sediments

Table. Explosives of adsorption coefficient (K_p) and organic carbon adsorption coefficient.

Explosives	Adsorption coefficient (K_p)	Organic carbon adsorption coefficient ($logK_{oc}$)
2,4-DNT	0.22-0.33	1.03-1.21
TNT	0.21-0.30	1.02-1.18
RDX	7.26-13.5	2.56-2.83
HMX	13.1-21.7	2.81-3.46

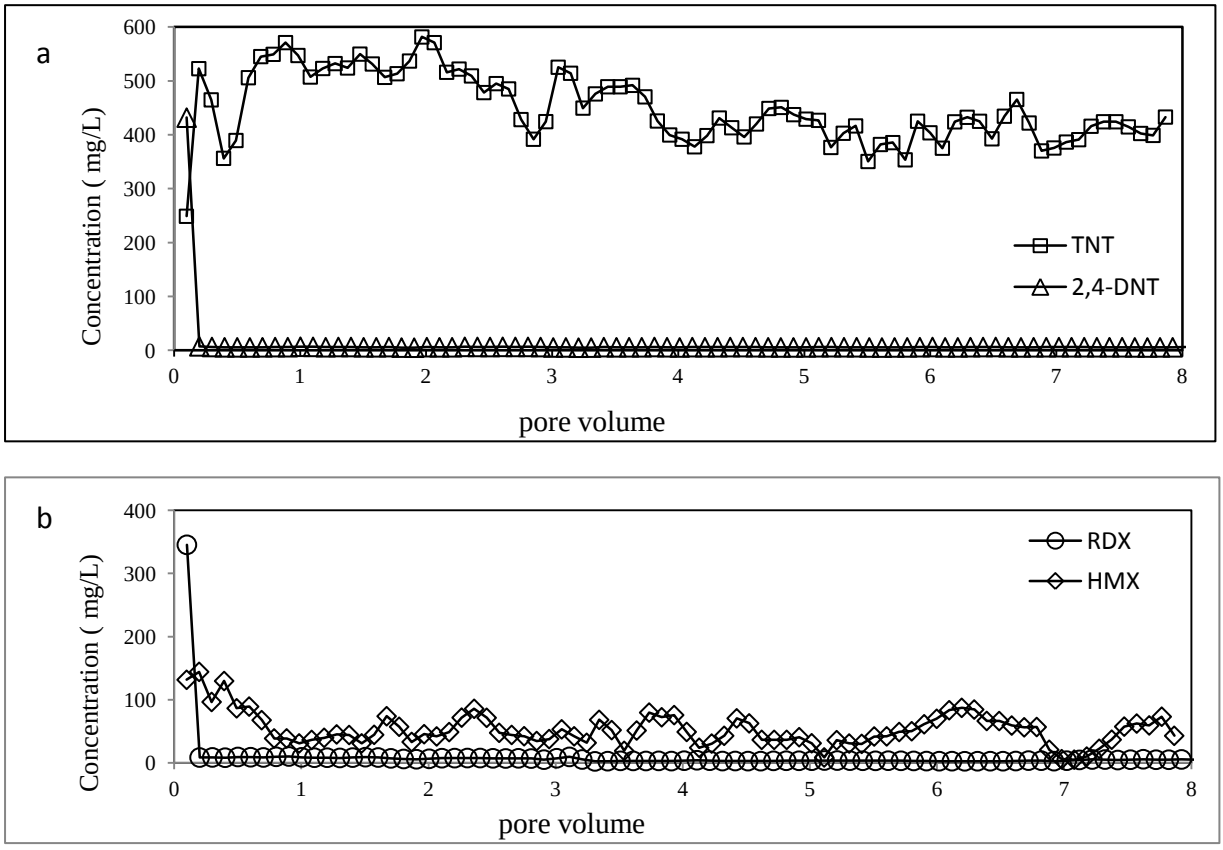

Figure 1. The elution profile of explosives by deionized water flushing.(a) Amount of TNT and 2,4-DNT. (b) Amount of RDX and HMX.

Modelling Degradation Kinetics of Organic Compounds in Contaminated Groundwater by UV-assisted Persulfate

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Extended abstract

Persulfate oxidation is an *in-situ* chemical oxidation (ISCO) method for the remediation of organic contaminated groundwater. In this study, UV-assisted persulfate oxidation was proposed to treat four organic pollutants commonly observed in contaminated groundwater, including toluene, ethylbenzene, trichloroethylene, and methyl *tert*-butyl ether (MTBE). Kinetic experiments were conducted using batch reactors with deionized water under various UV intensities and pH values. Experimental results show that the targeted contaminants can be quickly degraded in the UV/persulfate system within ~ 30 mins. A radical based kinetic model was developed to describe the degradation of the four targeted chemicals under UV/persulfate oxidation. The model predictions, based on independently measured radical concentrations and rate constants, agree well with experimental data, suggesting that the model is reasonable to describe the degradation of the tested organic compounds during UV/persulfate oxidation.

Keywords: Chemical oxidation, chemical probe, persulfate, radical, UV

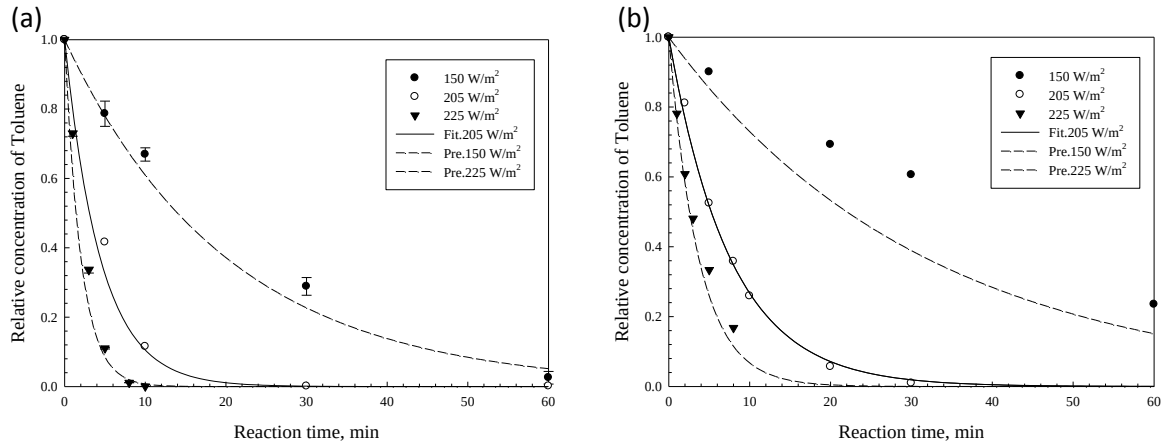

Figure 1. Simulated (solid line) and predicted (dashed line) models for toluene under UV/persulfate oxidation, where (a) is for pH at 3, (b) is for pH at 12.

Health Risk-based Remediation Technology

Dermal soil adherence in different activities for children

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Extended abstract

Children may exposure to non-volatile or semi-volatile contaminants in soils via dermal exposure or ingestion from soils which adhered on skin. Soil adherence is also used to estimate the soil ingestion rate. In the current study, we investigated the soil adherence for children in the kindergarten. We also investigated the effect of different activities, body parts and clothing on soil adherence. Total of 31 children (15 males and 16 females) were recruited from a kindergarten in Hualien. Washing samples were collected from hands, forearms, feet and lower legs after they conducted activities. The activities were grouped into 3 groups based on the intensity of interaction with soil: pre-activity, indirect contact scenario, i.e., kicked ball on grass and direct contact scenario, i.e. played in the sand pit. In order to obtain the soil loading, the surface areas of 4 body parts were also estimated. The non-parametric statistics were used. The geometric mean of soil loading for hand, forearm, foot and lower leg were, 0.0063, 0.0044, 0.0575 and 0.0038 mg cm^{-2} respectively in pre-activity scenario, were 0.0325, 0.0286, 0.0582 and 0.0119 mg cm^{-2}, respectively in indirect contact scenario, and were 0.1947, 0.1009, 0.0734 and 0.0368 mg cm^{-2}, respectively in direct contact scenario. For all 4 body parts, the soil loadings were all significantly increased in the order pre-activity scenario, indirect contact scenario and direct contact scenario. For all 3 scenario groups, the soil loadings were significant difference between 4 body parts. In pre-activity and indirect contact scenario, the soil loadings for foot were both highest among 4 body parts. However, the soil loading for hand was both highest among 4 body parts in direct contact scenario. We also found that the soil loading for lower leg was significant difference in pants groups. Compared to children who wore long pants or cropped pants, children who wore shorts or skirt had the highest soil loading. However, we did not found that any difference in soil loading for foot in shoes groups. In conclusion, the soil loadings for hand and foot were usually higher than the soil loadings for forearm and lower leg. We also found that the soil loading was increased with the intensity of interaction with soil. The clothing may affect the soil loading for the covered body part. However, the effect of different clothing on soil loading for different body part may be different, i.e. pants and shoes.

Key words: Children, soil adherence, loading, dermal exposure.

Health risk assessment of metals via soil ingestion among children in contaminated sites

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Extended abstract

Metals may accumulate in soils by various anthropogenic activities. Due to children's unique behaviors, they are often more vulnerable than adults to exposures to metals in soils, especially in contaminated sites. There are few studies to directly estimate soil ingestion. We used mass balance tracer method to estimate soil ingestion, and then we used these data to assess the health risk of metals in soils for children in contaminated sites. Total of 66 children were collected 3-days fecal samples and 1-day dietary sample to estimate soil ingestion using mass balance tracer method. Silicon (Si) was selected as the tracer. Each one contaminated site was selected from northern, central and southern Taiwan, respectively. We collected 4 soil samples around each child's house. The concentrations of metals (As, Cr, Cu and Hg) were measured by atomic absorption spectrophotometer (AAS). Monte Carlo simulation was used to estimate the chronic daily intake (CDI) of metals through soil ingestion for children. To determine the non-cancer risk assessment for metals in soil through ingestion, we were compared the CDI to oral reference dose (RfD_o). The estimated soil ingestion based on Si was 9.6 mg/day. The average Cr and Hg concentration in contaminated site in northern Taiwan were 51.8 and 0.195 mg/kg, respectively. The average Cu concentration in contaminated site in central Taiwan was 178 mg/kg. The average As, Cr and Cu concentration in contaminated site in southern Taiwan were 1.89, 44.9 and 2.73 mg/kg, respectively. There was no children's CDI of metals through soil ingestion exceeded the RfD_o in northern and central Taiwan. In southern Taiwan, only less than 2% children's CDI of As through soil ingestion exceeded the RfD_o for every age group.

Key words: Children, soil ingestion, metal, health risk assessment.

Sampling, Monitoring and Evaluation of site

Sampling, Monitoring and Evaluation of site

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Sampling, Monitoring and Evaluation of site

Application of Surgical Remediation to Complex Contaminated Sites in Taiwan

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Extended abstract

Because of geological heterogeneity, it is easily to misestimate the distribution of pollutants and to predict the transportation of pollutants difficultly during the investigation and remediation of groundwater contamination. Furthermore, the injection of gas and remediation medicaments or biological species cannot effectively transport to pollutant area of complex geology, especially in low-permeability strata. Therefore, it is necessary to develop Surgical Remediation(SR) for some geological heterogeneity complex sites. The Surgical Remediation is to applying high resolution of investigation techniques to get more underground characteristic, such as 3D pollutant distribution, geological distribution and biochemical information, and to using better remediation transportation techniques to overcome geological heterogeneity. For example, remediation medicament can be spread more widely to remediate pollutants in low-permeability strata.

A geological complex contaminated site in Taiwan, interbedded with sand and silty clay and low permeability reach to 2~3 orders, was studied in this research. The groundwater is highly contaminated with 1,2-Dichloroethane and Vinyl Chloride within low-permeability strata (silty clay). Therefore, the traditional gravity and compression remediation methods is invalid. We introduce the concept of SR, using Multi-Depth Pollutant Sampling Analysis, Multi-Depth Radon Analysis, Bacteria Flora Analysis, Multi-Depth Slug Tests, Well Log Analysis and Multi-Depth Flow Velocity and Direction of Single Well Test, to evaluate the 3D hydrogeology characteristic and the space-time variation of pollutants. The novel technique of Double Packer Injection Methods(DPIM), which could inject remediation medicament into the specific deep strata, was also applied in this site. Since DPIM would not change the original volume and structure of strata, it avoids the possibility of expanding pollutant area with artificial cracks. Finally, we use the groundwater flow direction and perpendicular direction to evaluate the overall mass flux variation, and combine with novel geophysical, Cross-Hole Logging Test to directly or indirectly evaluate remediation medicament variation during transportation. This research proves that SR can be effectively investigated underground characteristic, and remediation medicament can be efficiently injected and transport to the predicted direction in low-permeability strata .

Keywords: Geological heterogeneity, Surgical remediation, Double Packer Injection Methods, Geophysical survey

Cases Study of Applying TL-ERT to the Soil and Groundwater Contaminated Sites

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Extended abstract

The hydrogeology of the soil and groundwater contaminated sites can be investigated by applying Electrical Resistivity Tomography (ERT) method. By estimating the groundwater flow direction and distribution of contaminations, we could establish monitoring or sampling wells in potential pollution areas. ERT survey could delineate the contaminated areas with high concentrations in relatively simple geological sites. Even in the seriously DNAPL leakage cases, it is possible to directly detect the DNAPL pool. However, when the site condition is complex (e.g. the electrical characteristic of contaminants and geological materials is similar), it is difficult to distinguish the differences between contaminants and geological materials in electrical resistivity profiles. Therefore, the Time Lapse-ERT (TL-ERT) can be applied to monitor the distribution of electrical characteristic changes underground and to indirectly indicate the flow direction of contamination. Furthermore, the TL-ERT is also an efficient approach to evaluate remediation effectiveness in remediation or post-remediation sites. When the lapse of time is short, TL-ERT is similar to real-time monitoring. It is more efficient to estimate the transportation direction of pollutant or medicament by using TL-ERT combined with Cross-Hole Electrical Resistivity Tomography (CHERT). It can not only get high resolution electrical resistivity images but also increase the benefit of new establish wells.

Keywords: DNAPL, electrical characteristic, Time Lapse-ERT, Cross-Hole Electrical Resistivity Tomography, Geophysical survey

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The impact of surface runoff near wasted gas tunnels on the arsenic pollution of receiving waters at a contaminated abandoned copper mine and refinery site in Taiwan

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Extended abstract

There are three 40-years-old wasted gas tunnels in the abandoned Taiwan Metal Mining Corporation (TMMC) complex in Chinkuashih, New Taipei City, Taiwan. It was found that the residue in the gas tunnels or the soil near the tunnels contained high concentration of arsenic. However, in the field survey and pollution impact assessment conducted in the past, the impact on the water quality of receiving waters by soil erosion or surface runoff was not assessed. The results of the sequential extraction analyses indicate that more than 70% of arsenic is in the forms of amorphous and crystalline hydrous Fe/Al bound speciation, 3 to 30% is non-specific or specific bound arsenic species on the sample surface, only 1 to 5 % is residual form in the waste and soil matrixes. According to the results of BCR sequential extraction, no more than 30% of arsenic can be regarded as active based on acetic acid extraction procedure, and is even lower for samples having experienced longer weathering time. The total area of contaminated land in this site is about 25.8 hectare. Ninety five tons of soil will be eroded away per hectare per year, that is 2,400 tons of polluted soil in the whole contaminated site estimated by GIS and USLE calculation. The loading of arsenic from soil erosion is about 5.4 tons each year. The predicted arsenic concentration in the surface runoff would be 3.11 mg/L in the polluted area, and be diluted to 1.28 mg/L downstream with non-polluted surface runoff from the catchment. The concentration of As in surface water runoff collected near a waste gas tunnel was 1.5 mg/L, whereas the average concentration was only 0.2 to 0.5 mg/L in the contaminated catchment. Most of the arsenic in the water sample is in dissolved form, which might be released from the gas tunnels waste and polluted soil due to acidic leachate, then entrained by surface water flows or intermediate flow down gradient. The dissolved load contributes more to the arsenic concentration in the receiving waters than the particulate arsenic from the soil impacted by raindrops and mobilized by surface water runoff. The USLE is not suitable to estimate the concentration of arsenic in runoff in an acidic soil condition as that in this site. Therefore, it is not suitable to compare the arsenic concentration of water samples directly to the simulation results. In this study the arsenic speciation of gas tunnel waste and polluted soils with different weathering condition were revealed. The results can provide valuable information for the environmental hazardous assessment and risk management of this arsenic contaminated site.

Keywords: Arsenic (As), soil pollution, surface runoff, soil heavy metal fractionation, soil erosion

Table. Arsenic concentration of the residue in the waste gas tunnels or the soil near the tunnels

Sample	Water cont.	pH	As (total)	Arsenic extraction method							
				Wenzel method							BCR
				F1	F2	F3	F4	F5	Fsum	REC	F1
	%	–	mg/kg	mg/kg						%	mg/kg
S1	1.44	2.0	48,042	6,687	3,466	14,519	25,181	2,482	52,335	109	13,045
S2	2.72	3.7	13,597	1,021	1,674	7,390	2,953	386	13,424	99	2,695
S3	7.19	3.9	42,419	66	1,402	42,093	6,935	465	50,961	120	341
S4	2.34	4.8	6,183	24	606	4,400	984	88	6,102	99	216
S5	9.77	2.3	24,290	5,240	2,111	7,393	10,216	867	25,828	106	6,734
NIST 2710	–	–	617	2	79	516	64	17	679	110	9

Note: Wenzel sequential extraction method Fsum = F1+F2+F3+F4+F5; REC (recovery) = Fsum/As_{total}

Review and Improvement of Soil Gas Detection Method in Underground Storage Tank Systems

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Extended abstract

Since the promulgation of "Regulations for Installation and Management of Facilities for Preventing Pollution of Groundwater Bodies and Monitoring Equipment in Underground Storage Tank Systems" on January 14, 2011, approximately 70% of the underground storage tank systems in Taiwan performed routine monitoring by using soil gas detection method. However, current regulations only specify monitoring radius of soil gas monitoring well, permeability of the soil, and effective monitoring depth. Other related regulations, such as diameter, material and installation depth of the monitoring well are still lacking. Furthermore, current soil gas detection procedure requires 15-minute passive ventilation before sampling. This might cause sample dilution and lead to false soil gas analysis results. Therefore, it is suggested that 15-minute passive ventilation procedure needs to be replaced with direct purging of fresh soil gas and the volume of gas being purged will be calculated based on monitoring well diameter.

Some of the soil gas monitoring well was observed not to equip with perfect air-tight seal due to various installation defects. As a result, short circuiting (gas coming in from outside of the well during extraction) is happening frequently. On top of that, most old soil gas monitoring well used cast iron as casing material, which often leads to clogging problems due to rusting. This study is proposing a suitable soil gas monitoring well installation guidance by referencing to groundwater monitoring well installation design from various countries. Other than standardize soil gas monitoring well design, soil gas extraction time before sampling is also proposed for different monitoring well diameters in order to prevent dilution from ambient air.

It is proposed to replace cast iron with PVC as the soil gas monitoring well casing material. In addition, 0.5 mm screen slot size and higher permeable coarse sandy filter material should be used in order to effectively collect soil gas into monitoring well. Furthermore, to minimize difficulties of soil gas extraction in sealed well, minimum well diameter should be at least 2". Lastly, this study also suggests that soil gas detection should be conducted after minimum soil gas extraction time has been reached. The extraction time is calculated based on well diameter, effective well depth and extraction pump flow rate. Calculation formula is derived as follow:

$$t = r^2 \times \pi \times \frac{h}{Q}$$

t =min. extraction time (sec.)
r =monitoring well diameter (cm)
h =monitoring well effective depth (cm)
Q =extraction pump flow rate (sec.)

Keywords: underground storage tank system, soil gas detection, soil gas extraction time

Country Wide Dioxin Soil Survey and Evaluation by Utilizing Expedited Bioassay Screening Method

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Extended abstract

Since 1997, Taiwan EPA had issued regulations and standards to different types of environmental media, waste and pollution sources. Currently, understanding of entire country's soil dioxin concentration is still lacking and it is crucial for environmental authority to have a firm grasp of dioxin distribution. Moreover, dioxins analysis cost is high and time consuming; thus, EPA is promoting "screen first, analyze later" concept and establishing the expedited bioassay screening SOP to increase future emergency response time and save analysis cost. In 2011 and 2013, EPA had contracted Sinotech to conduct *"Method Development for Screening Highly Possible Dioxin Contamination in Soil Following by Identification of Contaminated Locations with Expedited Analytical Techniques"* and "*Research and Analysis of Soil Dioxin Contamination Investigation and Management in Taiwan Region*" to uncover the dioxin distribution situation in soil.

Initially, a total of 1,600 soil samples were collected and screened using bioassay screening method (CALUX). 230 samples were then selected to proceed with traditional HR GC/MS method confirmation. In addition, some selected samples were screened using locally developed luciferase cell strain. The purpose was to study method performance and make any future method improvement. The investigation areas included sensitive land uses (i.e. farmland, livestock farm, parks), areas near stationary pollution emission source, areas surrounding possible pollution sources (i.e. illegal dumpsite, landfill, disposal facility) from Taoyuan, Taichung, Changhua, Kaohsiung and Hualien. Finally, to foster expedited screening techniques in non-governmental organization, EPA had contracted private consulting firms (Sinotech and MWH Taiwan) to develop soil investigation plan and conduct data and correlation analysis. On top of which, EPA asked Environmental Analysis Laboratory to provide technical consultancy and conduct CALUX screening. Other team members included Cenprotech to conduct sample pre-treatment tasks, NCKU Sustainable Environment Research Center to conduct ELISA screening task, NPUST to conduct the locally developed luciferase cell strain screening task and Tajen University to conduct non-governmental CALUX screening task.

All the soil screening and analysis results were below current soil pollution control standard (1000 ng I-TEQ/kg). However, it is suggested that soil survey should be continued for the rest of Taiwan in order to complete baseline survey of dioxin concentration in soil. Locally developed luciferase cell strain analysis performance had improved annually. It is suggested that this method to be continually improvised and turn commercialized to compete with other screening method in the market. Other related expedited screening techniques should be stressed more on personnel training and experience transferring.

Keywords: CALUX, expedited bioassay screening, locally developed luciferase cell strain

Application and Case Studies of Onsite Screening Techniques for Chlorinated Contaminated Site Investigation

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Extended abstract

Due to dense non-aqueous phase liquid (DNAPL) unique characteristic, the investigation and remediation associated with its releases to the environment is usually complex, time consuming and expensive. In the past, soil and groundwater investigation often involves with direct sampling and laboratory analysis, which often lead to high investigation cost. Therefore, various onsite screening techniques or tools are developed to meet the needs of contaminated sites investigation and remediation. They include photoionization detector (PID), flame ionization detector (FID), gas detection tubes, membrane interface probe (MIP) and time-of-flight mass spectrometry (TOF-MS). With the assistance of these screening tools, better understanding of the contamination (i.e. contaminant types, lateral and vertical extent of contamination) can be acquired. In addition, these tools also can be helpful in planning the next stage of investigation, such as sampling location, sampling depth, type of analysis, etc. Onsite screening techniques have more advantages over traditional direct sampling & analysis method when it comes to chlorinated contaminated site investigation.

Currently, it is commonly seen that most investigation actions adopt a 2-stage investigation process. The 1st stage uses onsite screening techniques, such as MIP and soil gas detection and sampling. According to the results, temporary well is installed at location where it is deemed to have possible groundwater contamination. If temporary well concentration is detected above groundwater control standard, standard monitoring well will be installed in the 2nd stage. In references with the investigation results from 5 different projects of "Investigation and Verification of Soil and Groundwater Chlorinated Solvents Pollution Potential in Operating Factories", if unusual screening result is observed (i.e. readings from ECD/FID on the MIP is higher than background level, color is changed in gas detection tubes), installation of temporary well can be skipped and directly proceed with standard monitoring well installation. Historical groundwater data from most groundwater contaminated sites confirmed that ECD/FID readings on the MIP are at least 5 times higher than background level. To sum up, it is proven that onsite screening technique can speed up investigation process and save on the overall budget. In addition to the fundamental principal, applicability and special attention of the various onsite screening techniques, this poster will also provide in depth description of investigation steps as well as with real case studies.

Keywords: Onsite screening, soil gas sampling, MIP, TOF-MS

Use of Compound Specific Stable Isotope Analysis to investigate sources of Chlorinated Ethenes in Contaminated Groundwater: A Case Study in Taiwan

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Extended abstract

Chlorinated ethenes (CEs) are common soil and groundwater contaminants due to the widely use of tetrachloroethene (PCE) and trichloroethene (TCE) as industrial solvent. The crucial issue of successfully CEs removal in groundwater is finding the sources at contaminated filed sites. Determination of carbon ($\delta^{13}C$) and chlorine ($\delta^{37}Cl$) isotopes ratios offers a potential tool to find and distinguish the different sources of CEs contamination in subsurface. In this study, compound specific stable isotope analysis (CSIA) was used, in conjunction with concentration data and groundwater flow data, to investigate CEs sources in contaminated groundwater and evaluate the relationship of potential CEs contaminated sources between different factories. One selected site in western Taiwan, where includes at least five factories (A to E), has been detected CEs concentration in groundwater over the regulation of groundwater pollution control standard (GPCL) in Taiwan. A total of fifteen monitoring wells were sampling groundwater in April 2014. The volatile organic compounds (VOCs) in groundwater were analyzed. Throughout the study, we have obtained the following conclusions: (1) The VOCs concentration data showed that fourteen samples were detected both PCE and TCE presenting in groundwater. Only one groundwater samples in monitoring well B00152 has been detected the PCE concentration (0.0802 mg/L) over the GPCL. (2) The $\delta^{13}C$ and $\delta^{37}Cl$ isotope data indicated the PCE contamination was caused by three different sources which located at facility A、B and D (see Figure 1). (3) One primary contaminated source was identified at well site of B00335 at facility A region. (4) Meanwhile, both $\delta^{13}C$ and $\delta^{37}Cl$ isotopes data and patterns of PCE distribution indicated the same contamination source at facility B and C. This study contributes to the application of CSIA as a tool for investigating source of chlorinated solvents contamination at field sites.

Keywords: groundwater contamination, compound specific isotope analysis (CSIA), chlorinated solvent

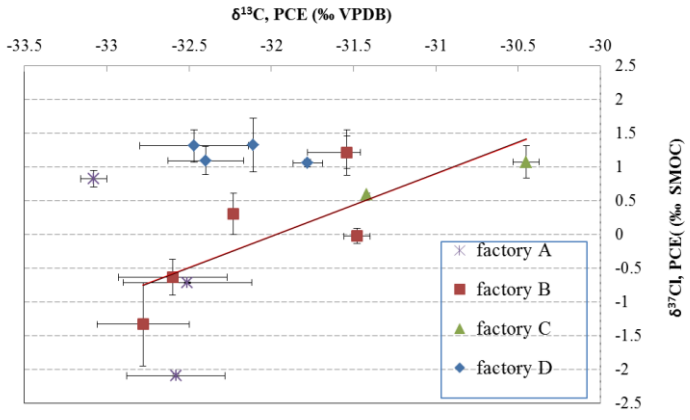

Figure 1. Dual stable carbon-chlorine isotopes plots for PCE sample collected from the monitoring wells at the four factories A to D. The isotope ratio data at factory B and C is followed the Rayleigh equation implied the same source. Isotope ratios data at factory E. are not quantified (no shown). The error bars show the standard deviation of the isotope measurements.

Behavior of Nitrogen Discharge from Mortalities Burial in Groundwater

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Extended abstract

A lot of burial sites were constructed in a short period in order to prevent the rapid spread of the virus since the diseases were broken out. It is estimated that secondary contamination of leachate leaking occurs from some of burials constructed in unsuitable area for standard of selection. Leachate from burial sites includes high concentration of ammonia (maximum concentration of 14,400 mg/L). Leachate may impact on human health and ecological environment if it leaks from the burial sites. This study analyzed the behavior of nitrogen including in the leachate originated from the burial sites. We set up columns for simulation of the saturated and unsaturated soil aquifer. Leachate was collected from swine mortality. The study results of saturated soil showed that approximately 39% and 14% of ammonia were removed by soil adsorption and nitrification respectively. It is estimated that some portion of nitrate nitrogen was removed by denitrification. The results of unsaturated soil showed that approximately 45% and 27% of ammonia were removed by soil adsorption and nitrification respectively. The attached nitrogen on soil surface can be flowing into groundwater in the various environment of soil aquifer and continuously impacts on the groundwater.

Keywords: Mortality burial, leachate, Groundwater, Nitrogen, Column test

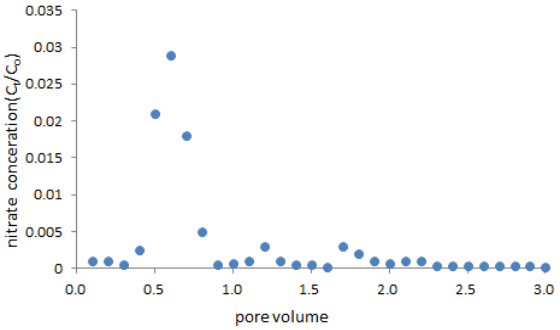

Fig. 4 Results of the column test in the saturated soil (C) Nitrate

Table 1. Summary of diffusion coefficients and retardation factors for saturated soil

	Chloride	Ammonia	Nitrate
D (cm^2/s)	0.95	0.07	0.84
R	-	6.6	1

Breakthrough curves shown in Fig. can be represented as advection-diffusion equation shown in Eq. (1).

$$\frac{\delta C}{\delta t} = D^* \frac{\delta C^2}{\delta^2 x} + v\frac{\delta C}{\delta^2 x} + R \qquad (1)$$

D* : effective diffusion coefficient(m^2/s),

V : advection velocity(m/s),

R : retardation factor(dimensionless)

Diffusion coefficient (D) can be estimated using Eq. (2) when advection equation is homogeneous in soil pore (Rifai et al., 1956).

$$D = \frac{V \times L}{4\pi V_0^2} \times \frac{1}{S_0} \qquad (2)$$

D : diffusion coefficient(cm^2/min),

V_o : pore volume when C/C_o is 0.5 pore volume,

S_o : slope when C/C_o is 0.5,

V : velocity of soil column (cm/min)

Quantification of Uncertainty Associated with Environmental Site Assessments and Its Reduction Approaches

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Extended abstract

Uncertainty associated with a sampling method is very high in evaluating the degree of site contamination; therefore, such uncertainty affects the reliability of precise investigation and remediation verification. In particular, in evaluating a site for a small-sized filling station, underground utilities, such as connection pipes and oil storage tanks, make grid-unit sampling impossible and the resulting increase in uncertainty is inevitable. Accordingly, this study quantified the uncertainty related to the evaluation of the degree of contamination by total petroleum hydrocarbon and by benzene, toluene, ethylene, and xylene. When planning a grid aimed at detecting a hot spot, major factors that influence the increase in uncertainty include grid interval and the size and shape of the hot spot. The current guideline for soil sampling prescribes that the grid interval increase in proportion to the area of the evaluated site, but this heightens the possibility that a hot spot will not be detected. In evaluating a site, therefore, it is crucial to estimate the size and shape of the hot spot in advance and to establish a sampling plan considering a diversity of scenarios.

Key Words: Uncertainty; Protocol, Assessment, Site contamination, Sampling planning

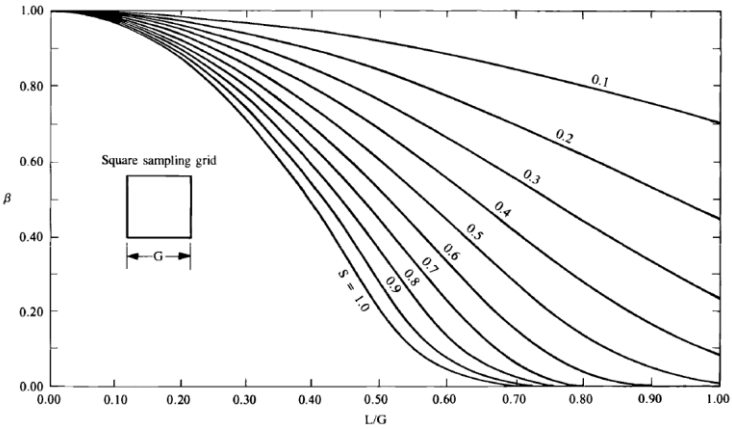

Fig. Curves relating L/G (L: length of semi-major axis, G: grid spacing) to consumer's risk, β, for different target shapes when sampling is on a rectangular grid pattern

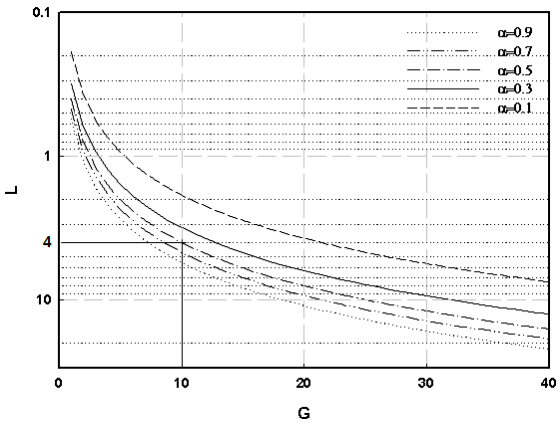

Fig. Curves relating grid distance, G, and the radius of circular hot spot, L, by confidence level, α

Statistics in the Power Analysis of Soil and Groundwater Survey with Chlorinated Organic Compounds

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Extended abstract

Chlorinated solvents are dense nonaqueous phase liquid (DNAPL), its mobile and non-mobile phases are deeply influenced by complex hydrogeological condition. Due to the capillary action in the soil, the trapped residual DNAPL whose shaped or hanging like a drop, is difficult to survey. It is the result that the chlorinated solvent pollution lawsuits are often complex and diverse. To clarify the environmental damage associated with the fact of the human operation, it needs a variety of causation theories, such as equivalence theory, materiality theory, and the theory of statistics and probability, or even a combination of theories correspondingly. Therefore, it must make the strong link of in-situ survey to identify the causation between certain factors and the pollution. According to most of today's ideas of law, the theory of statistics and probability can be considered the revision of equivalence theory. The necessity, which is the causation of equivalence theory, is replaced as the concept of probability. The probability can be high or low, however, the long-term of expectations are stable in the Law of Large Numbers. Meanwhile, that is also regarded as the relationship of logical rule in law.

In this paper, there are statistics of 120 sites with chlorinated organics contamination of soil and groundwater investigation in different geological conditions of Taiwan. Using the testing statistical hypothesis is to interpret the correlation of three investigating procedures, such as soil sampling analysis, soil gas sampling with detector tube and groundwater sampling analysis. The results show that it is mutually relevant of three investigating procedures at the significant level of 0.05. For the composed of ground conditions, it is without the relevance. Especially, at the significant level of 0.1, there are no differences between the groundwater sampling analysis and soil gas sampling with detector tube. The detection ratio of exceeding the pollution control standards is not divergence. Therefore, the suggestion of the most objective investigating procedures is: first, doing the groundwater sampling analysis to look for location of leaking source, second, operating the soil gas survey with detected tube to strength the illumination of DNAPL residual existence in the unsaturated soil, especially in the close investigation near by the leaking area and source area.

Keywords: Testing Statistical Hypothesis, Soil and Groundwater, Chlorinated Solvents, Detection Ratio of Pollution, Law of Large Numbers

Analysis of Potential Characteristic Quantification Factor for Environment Site Investigation in Soil and Groundwater Chlorinated Solvents Pollution Potential in Operating Factories

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Extended abstract

There are different understanding and planning to the investigating strategies and potential pollution areas assessment in the ASTM ESA phase I process between operating factories and abandoned factories. Generally, it is relatively difficult to reconstruct abandoned factories because of lack of site information, such as the land extent and manufacturing operation. On the contrary, operating factories is relatively easy to manage. However, it could be meet the biggest challenge that the company refuse to provide factory formation and manufacturing process, important related parties or employees refuse to interview or avoid cooperating, so that the site investigation assessment is limited. Due to industrial safety and manufacturing process confidential, the consideration of industrial operation with the influence of legal prohibition, the company usually resists and circumvents the investigation based on public power of government. Due to reinforcement of operation area, actual potential pollution location is difficult to evaluate. Therefore, environment site investigation in the ASTM ESA phase I process need to build an initial quantification mechanism to avoid subjective determination of staffs. This article use the statistics such as the receiver operating characteristic curve (Figure), simple logistic regression analysis and Pearson's correlation coefficient (Table), to do the differential diagnosis on the initial quantification mechanism in the 90 operating factories. During progressively updating potential factors of quantification mechanism by the investigation results, we find that to observe and revise the potential factors progressively could increase the capability for the quantification mechanism.

Keywords: Environment sites investigation, ROC curve, Correlation coefficient, Logistic regression analysis, Initial quantification mechanism

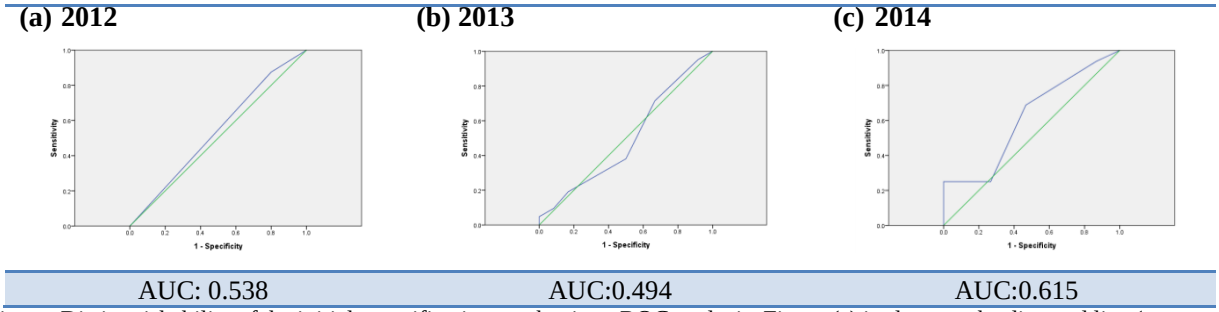

Figure: Distinguishability of the initial quantification mechanism- ROC analysis. Figure (a) is closer to the diagonal line (green line). Figure (b): Through the feedback of 2014, the weighting factors in the initial quantification mechanism is updated, whose is the result in the large variation of the ROC curve. Figure (c) means the higher sensitivity and lower false positive rate than years.

Table. Result of Pearson's correlation coefficient

Year	Variable	Count	Mean	Median	Minimum	Maximum	Std. dev.	R （P-value）
2012	A	26	1.0096	0.7	0	4.02	1.1839	0.034（0.870）
	B	26	97.8462	100	86	100	5.1513	
2013	A	33	0.8167	0.78	0	3.01	0.8823	0.014（0.938）
	B	33	77.3636	75	63	100	8.8981	
2014	A	31	0.9274	0.22	0	3.95	1.2336	0.434（0.015）
	B	31	63	63	50	100	10.4913	

Note：1. Null hypothesis: The coefficient $\rho \neq 0$ (two-tailed test). 2. Variable A: the correlations between a logarithmic multiple of the concentrations exceeded the pollution in soil or groundwater control standards. Variable B: the scope of the initial quantification mechanism.

Tentative Exploration into Common Emerging Contaminants of Soil and Groundwater in Chemical Engineering Process and Waste Disposal Site

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Extended abstract

Over the last decade, social pollution caused by domestic industry make a critical threat to land resources and living environment. Information about the chemical substances used in industrial process with high risk of contaminations is still not completely revealed. Until 2010, the circulation of chemical substances in Taiwan is close to the worldwide (more than 60,000 kinds). Nowadays, Taiwan Toxic Chemical Substance Control Act has listed 173 kinds of controlled substances (302 types with a view to dissimilar toxic chemical substances). For more improvement on the chemicals management, Amendments of Toxic Chemical Substance Control Act completed Third Reading at the Legislative Yuan on November 22, 2013, to demand the spirit of source management of chemical substances into the legislative intent, as well as establishment chemical registration system and toxic substances release information disclosure for public. Soil and Groundwater Pollution Remediation Act is announced on November 21, 2011. To this day, summation of organic compound items listed in Control Standards for Soil and Groundwater Pollution is 53. It is necessary to review the pollution control standards continuously. In this paper, there is contamination composition analysis in the soil and groundwater samples (64 samples, showed as Table) and comparison with the characteristic of industrial process chemical plant equipment, so as to further assess whether the leaks related to the process plant matter within, especially in 7 investigating sites with a large number of operations have been or are currently continuing the industrial chemicals, such as chemical manufacturing chemicals, pesticides and solvents deployment, waste disposal process. To compare raw materials and finished products in manufacturing process, and deeply understanding of the level of chemicals related applications, it is in the consequence of the used chemicals in sites during the operating period. There are 35 kinds of chemical compounds listed in U.S. Clean up Level Table and classified by International Agency for Research on Cancer. Among them, 1,4-dioxane and trichlorobenzene could list in watch list to be pollution control standards for the future amended law, especially 1,4-dioxane, which is concerned in different manufacturing process.

Keywords: Soil and Groundwater, Emerging Contaminants, Contamination Composition Analysis

Table Samples are related of site information and industrial process

Industrial process		Pesticides and solvents deployment process			Chemical manufacturing process			Waste disposal process	Total
Site #		#821010	#441010	#291020	#031021	#411020	#154020	#081010	
Soil sample	VOCs	3	3	3	2	-	2	-	13
	SVOCs	2	2	2	2		2		10
Ground water sample	VOCs	2	5	6	5	3	2	2	25
	SVOCs	2	1	3	3	3	2	2	16
Total		9	11	14	12	6	8	4	64

A Study on the Characteristics of Biochar with the Sludge of Sewage by Low Temperature Hydrothermal Carbonization

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Extended abstract

This study proposed a low temperature hydrothermal carbonization to treat and recycle sewage sludge. Such a reaction was used to identify the optimal conditions to produce biochar. A chemical activation process was also introduced to develop the micro pores of the produced biochar. To produce biochar, the original material, sewage sludge, of 50 g was put in a reactor and experimented at 220, 230, and 240℃ for 1, 2, 3, 5, 8, and 10 hours. In Batch 1., the optimal reaction temperature for the chemical activation of biochar was determined by varying the reaction temperature at 500, 600, and 700℃ for 60 minutes each. In Batch 2., based on the identified optimal activation temperature, the optimal reaction time for the chemical activation of biochar was determined by doing an experiment for 30, 60, 90, and 120 minutes. As a result, the optimal production conditions of biochar and activated biochar were correlated with the iodine adsorption capacity. The iodine absorption capacity was assessed according to the experimental method prescribed in KS M 1802 of Korean Industrial Standard. The optimal conditions to produce biochar and activated biochar were 230℃ and 8 hours and 600℃ and 60 minutes, respectively. Those conditions were used to conduct an isothermal adsorption experiment for removal efficiency. Heavy metals such as arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn) and nickel (Ni) were analyzed under the standard method for waste in Korea. Lead recorded the highest heavy metal adsorption efficiency of biochar, being followed by copper, cadmium, zinc, and nickel. Arsenic was hardly adsorbed overall. The heavy metal absorption efficiency of activated biochar was shown more than 80% in all the heavy metals except for arsenic, which was not adsorbed relatively and recorded adsorption efficiency about 20~40%.

Keywords: hydrothermal carbonization, biochar, sewage sludge, adsorbent, heavy metals

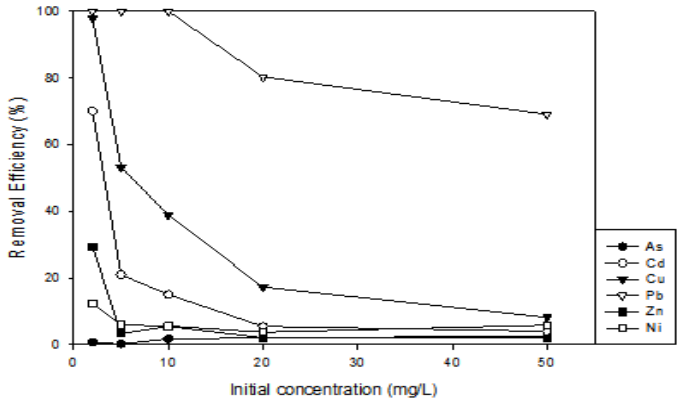
Heavy metals analysis*[1] of sewage sludge

	As	Cd	Cu	Pb	Zn	Ni
Standard*[2]	1.50	0.30	3.00	3.00	-	-
Sewage sluge	N.D*[3]	N.D	0.004	**0**.760	0.271	N.D

*[1] KSLT: Korean Standard Leaching Test

*[2] 「Wastes Control Act」 Enforcement regulations

*[3] N.D: Not Detected



Removal efficiency of heavy metals by biochar

The assessment of energy potential with bulky waste in Seoul metropolitan

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Extended abstract

The MOE(Ministry of Environment) has classifies 4 types of solid fuels as RDF(Refuse Derived Fuel), RPF(Refuse Plastic Fuel), TDF(Tire Derived Fuel) and WCF(Wood Chip Fuel) in Korea at 2012. However, the MOE reclassifies, the solid fuels with SRF(Soild Recovery Fuel) and Bio- SRF. The conversion of SRF is reduced since the fuel of the grade standards economic efficiency and ease of recycling of waste increased. In this study, investigating current states of household bulky waste of Seoul, to produce, collect and transportation and disposal by for bulky waste recovered and analyzed by applying a new SRF fuel standards, it is intended to evaluate the potential energy of bulky waste. According to report of waste- meter-rate system in 2010, Dongdaemun-Gu is a district of close bulky waste average emissions of Seoul, and have an important facilities of transshipment bulky waste, so we selected Dongdaemun-Gu and analysis. According to process of Dongdarmun- center, bulky waste is classified into four-case, metals, sponges, woods and inclusion, all be classified as and dismantling by hand. Inclusion is difficult to recycle materials from bulky waste, all things now has incinerated in Dongdaemun-Gu. At this time, transport and incineration costs are required was about 300 million won in 2012. As the results of survey in Dongdaemun-Gu, electronic goods sent to the recycling center are recycled, also known that one of the bulky waste that are classified, such as woods that can be incinerated is recycled. So, selected as inclusion that was incinerated to apply the SRF fuel standard. It is impossible to discover the differences in characteristics due to bringing location and period in terms of the quality of the fuel. In addition, the results of conformity assessment of quality standards, it will appear to be appropriate for all items with the exception of moisture, it is expected that it may be the value of the low calorific power is the most important factor in the quality standard of the fuel in particular showed similar values at 4,000 kal / kg, to produce a homogeneous energy. However, in the case of moisture, over some of the moisture standards value under the influence of rainfall, it's expected that measures such as shield system or roof can block rainfall to the required.

Keyword: waste-to-energy, SRF, RDF, bulky waste

The Characteristics of the Bio-char with the Food Waste by Hydrothermal Carbonization

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Extended abstract

In this study, bio-char was produced by using Hydrothermal carbonization (HTC) which is one of the low-temperature thermal decomposition method to treat foodwastes. Food wastes used in this study were taken from S university students restaurant in Seoul. The amount of Bio-char produced were 5kg, 10kg, 15kg and reacting time of 2 hours, 4 hours and 6 hours at 200℃. Pressure was retained 1.5 Mpa for derived appropriate condition. After deriving the appropriate conditions, reaction was carried out at pressure of 1.0 Mpa and 1.8 Mpa. If the pressure is higher than the reactor conditions, the decompression was performed venting for retaining pressure. After pretreatment, bio-chars were analyzed such as iodine adsorption capacity, scanning electron microscopy (SEM), salinity, ultimate analysis and heating value. Iodine adsorption capacity carried out for determining whether soil amendments or adsorbent. Food wastes of 10kg with reaction time of 6 hours and the pressure of 1.5Mpa is the highest results that is 421.78 iodine mg/g. The result is significantly lower than iodine adsorption capacity of activated carbon that is 900~1100 iodine mg/g. So, bio-char need pretreatment for increasing the specific surface. Initial concentration of Salinity of food wastes were over 2.24%, but after reaction it decreased from 40.51%~66.00%. However, in fertilizer process specification since August 1998 implementation, if food wastes used as soil amendments, salinity is regulated to 1% or less. Thus, it is required pretreatment process for making bio-char of lower salinity.

Keywords : hydrothermal carbonization, biochar, foodwastes

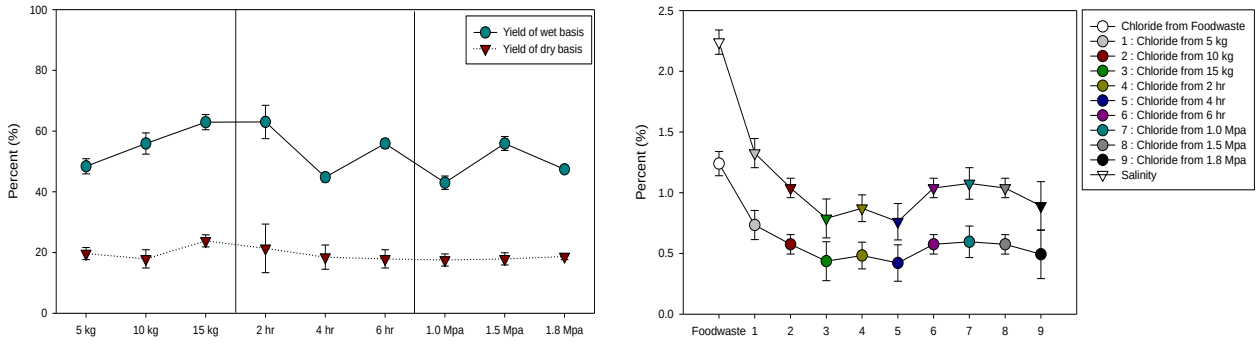

Fig. 1. The yield and salinity of bio-char with food wastes

Characteristic Analysis of Municipal Solid Waste (MSW) in G City

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Extended abstract

In 2012, the amount of all wastes in Korea was 382,009 ton/day, the amount of municipal wastes in all wastes is 48,990 ton/year and about 46 % of municipal wastes are being incinerated. However, there is a tendency that the air quality regulations have also been strengthened more and more by the Kyoto Protocol, the incineration capacity of incineration facilities per time is between 25kg and 200kg are subject to apply dioxin emission standards from January 1st 2006. Many facilities which are not satisfied with this standard are closed, so the number of the incineration facilities reduced(672 (2010) → 611 (2011)→ 552 (2012)). But I think that it is absolutely necessary to incinerate wastes because of reducing the volume and mass of wastes, recovering the waste heat and being consistent with a domestic trend as resource recycling waste management system, the goal of which is a conversion. In order to achieve recovering the waste heat efficiently through incineration, above all, we need to know the physical • chemical composition and the heating value of wastes in G city. And then it is possible to run the resource recovery facility economically and systematically.

The primary goal of this study is to understand exactly the composition of MSW in G city and to know whether the composition of MSW in G city is proper or not when the resource recovery facility runs. So, we perform the sampling per each site in waste repository and conduct the analysis of Bulk density, physical • chemical composition, three component(moisture, ash, combustible) and heating value.

As a result of the analysis, the average value of bulk density was 266.05 g/L. And the physical composition of MSW separates two kinds of materials (combustible and incombustible). At first, combustible materials occupy 94.26% of all wastes consisting of paper (30.43%), plastic & vinyl (22.95%), fiber (10.84%), foods (10.64%), other inflammables (9.62%), diaper (7.95%), rubber & leather (0.92%) and wood (0.91%) in sequence. And incombustible materials are composed of glass & ceramics (2.24%), other incombustibles (2.04%), nonferrous metal (0.98%), sand (0.48%), and ferrous metal (0%) in order. And three composition of MSW represents 43.81% of moisture, 44.18% of combustible and 12.01% of ash averagely. The chemical composition of MSW shows that Carbon(C) is 59.23%, Hydrogen(H) 8.83%, Oxygen(O) 30.11%, Nitrogen(N) 1.54%, Sulfur(S) 0.27%, and Chloride(Cl) 0.02%. At last, higher heating value with moisture was 2889.60 kcal/kg and lower heating value with moisture was 2415.99 kcal/kg in heating value.

Keywords: Waste, Bulk density, Three components, Physical•Chemical composition, Heating Value

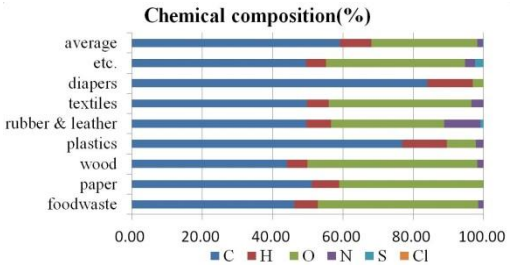

Figure 2 Chemical composition per each physical composition (using Elementar Analysensysteme, Standard Method)

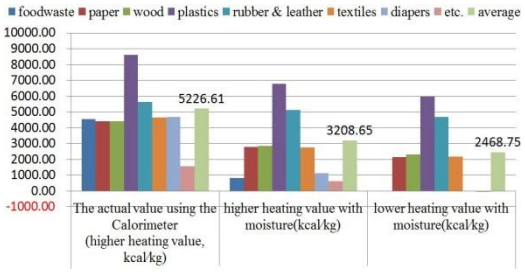

Figure 1 Heating Value per each physical composition (using Calorimeter)

Linking Corporate Social Responsibility and Enterprise Sustainability – Case Study for the Chemical Sector

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Extended abstract

To achieve sustainable development the Taiwan petrochemical industries need to focus on their corporate social responsibility (CSR). One of the most critical environmental CSR challenges for the petrochemical industries in Taiwan is the soil and groundwater contamination issues.

Key stakeholders for this subject have been identified as follows, the government, civil society, general public, petrochemical industries, suppliers, and investment parties of the petrochemical industries. Successful fulfillment of CSRs in soil and groundwater contamination relies largely on the level of cooperation among government, technical research institutions, and the petrochemical industries themselves. The government may be assumed the roles of supervising, helping, and encouraging through incentives for undertaking CSRs by the petrochemical industries in soil and groundwater contamination. The technical research institutions may work with the industries to develop innovative soil and groundwater remediation techniques or products. The petrochemical industries should dispatch adequate team of staff to be responsible for the soil and groundwater contamination prevention or remediation. Relevant and updated soil and groundwater information of each petrochemical company should be disclosed and disseminated publicly while the CSR related works be initiated and adopted internally by the individual petrochemical industries.

Some of the current Control or Remediation Sites for soil and groundwater contamination in Taiwan are petrochemical industries related. If the petrochemical industries could fulfill the CSR on the soil and groundwater contamination, it would have positive impact to the overall environment and outlook for a more sustainable development of the Taiwan petrochemical industries.

Application of Time-Frequency Analysis on Groundwater Level in the Coastal Region

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Extended abstract

Assessing groundwater flow pattern is an important task for groundwater investigation and remediation. The groundwater table in the coastal region is usually associated with tidal or anthropogenic actives, resulting in groundwater flow being hardly estimated. This study aims to elucidate the brief factors affecting the groundwater table of the study site, which located at central Taiwan nearby Taichung Harbor, by using time-frequency analysis. The time–frequency analysis is a technique that studies a signal in both the time and frequency domains simultaneously, using various time–frequency representations. In the study site, the water levels of 7 monitoring wells (W1~W7) are recorded during 6 months. According to the analysis result, the groundwater table has been affected by M_2 (1.932 cycles/day) and S_2 (2.000 cycles/day) of partial tides insignificantly, and the daily average water level difference from 0.8 to 6.8 cm. In contrast, the parts of the monitoring wells are significantly affected by anthropogenic actives, and the daily average water level difference achieves 24.9 cm. Furthermore, compared to the inland, the drainage systems located in the southern and northern parts of this area influenced the water level significantly.

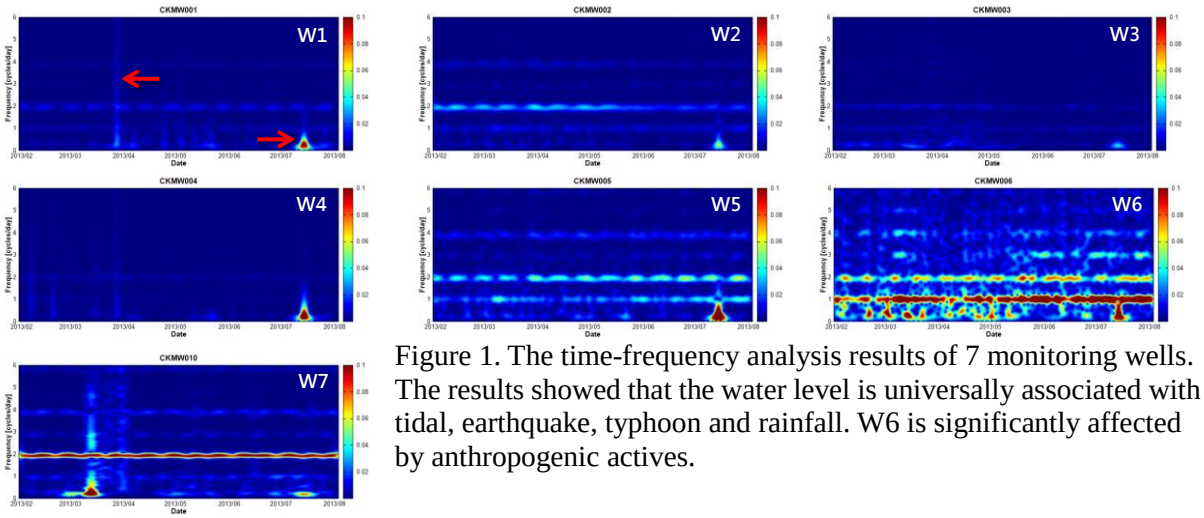
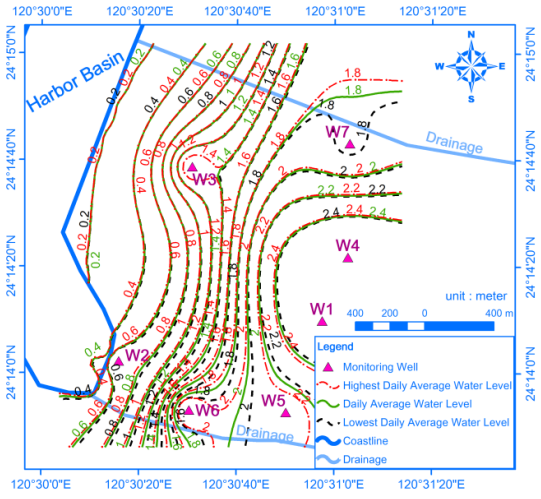


Figure 1. The time-frequency analysis results of 7 monitoring wells. The results showed that the water level is universally associated with tidal, earthquake, typhoon and rainfall. W6 is significantly affected by anthropogenic actives.

Figure 2. Contour map of daily average water level. The results showed that the drainages at northern and southern are more influence groundwater level than inland.



APPLICATION OF NEW TECHNOLOGIES FOR DIOXIN REMEDIATION IN SOIL IN VIETNAM

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Extended abstract

Throughout history, during the war, Vietnam was subjected to the widespread spraying of the chemical defoliants Agent Orange, containing the most toxic dioxin congener 2,3,7,8 TCDD[1]. At the former US Army airbases such as Da Nang, Bien Hoa and Phu Cat, where were loaded, mixed and transported of herbicides for "Operation Ranch Hand" (1961-1971), concentrations of 2,3,7,8 TCDD in soil and sediment were found to be very high. These airbase areas were called "dioxin hotspots" in Viet Nam. Due to the high adsorptive property and persistency, dioxins are accumulated and remain in environment for a long time.

This paper reviews the remediation technologies which are applying to clean up dioxin contaminated soil in Vietnam in order to provide the audiences useful information of many aspects and discuss how shoud be propriatly technolgies for the chacteristes of contaminated areas and condition of country.

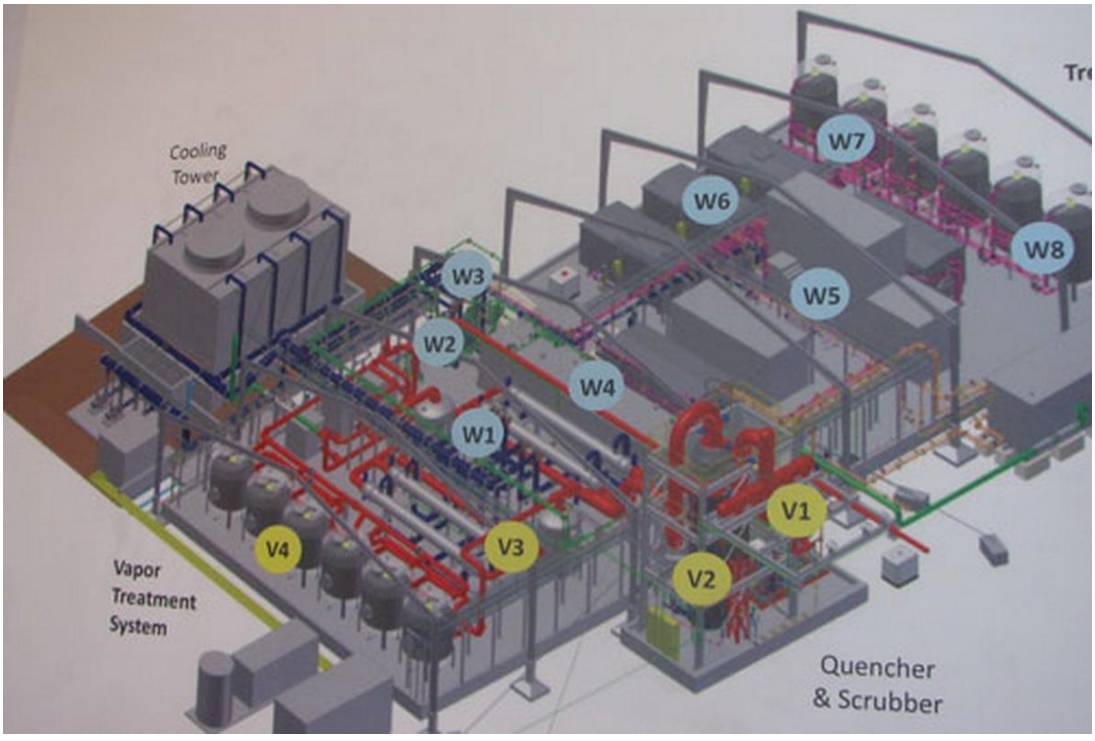

Fig 1. Scheme of thermal treatment technology for dioxin contaminated soil in Da Nang Airbase .

Linking microbial parameters to agricultural soil quality in urban area

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Extended abstract

Urban agriculture is receiving attention nowadays as well-being and new recreation trend; however, soil quality in urban areas is questionable due to the continuous exposure of various pollutants. This study aims to evaluate the urban agricultural soil quality via its microbial properties. Soil samples were classified into two groups, organic or inorganic, depending on the type of fertilizers. Enzyme activities such as dehydrogenase, β-glucosidase, arylsulphatase, urease, and alkaline and acid phosphatase, and soil chemical properties were determined as dependent variables. Fatty acid methyl ester (FAME) analysis was done to assess soil microbial community composition, and its relationship with soil enzyme activities was examined. Microbial community richness and enzyme activities were highest in the organic soil group. The total soil enzyme activities in both organic and inorganic soil groups showed good correlations with the soil microbial community composition. Especially in microbial community-rich organic soil group, available nutrients were highest with compatible soil pH for their availability. Hence, the dynamic interaction between total soil enzyme activity and microbial community composition is applicable to determine the urban soil quality. This study was carried out with the support of "Cooperative Research Program for Agricultural Science & Technology Development (Project No. PJ010182042014)", Rural Development Administration, Republic of Korea.

Keywords: Soil enzyme activity, Soil microbial community, Soil amendment, Urban agriculture

Potentially toxic element contamination and its impact on soil biological quality in urban agriculture: A critical review

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Extended abstract

Concept of urban agriculture is often used along with urbanization and industrialization. Around 15% of global food production comes from urban lands, making urban soil quality a vital concern. Potentially toxic elements (PTE) may contaminate urban soils through vehicle emissions, household waste, industrial effluents, and atmospheric depositions. Toxic metals, lead, nickel, zinc, copper, and chromium have been identified as the key PTEs that cause severe contaminations in worldwide. Lead contamination is the most serious issue in many urbanized areas due to heavy traffic. High PTEs concentrations in soils adversely affect microbial communities and enzyme activities while degrading the biological soil quality and threatening the healthy food production in urban areas. This study was carried out with the support of "Cooperative Research Program for Agricultural Science & Technology Development (Project No. PJ010182042014)", Rural Development Administration, Republic of Korea.

Keywords: Soil pollution, Soil health, Biological Soil Quality

A Novel Screening Method for Agricultural Land with High Potential of Heavy Metal Pollution in Taiwan

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Extended abstract

Soil is not only the essential resource for our survival, but also the fundamental basis for agricultural production. The development of Taiwan's economy has made great strides over the past few decades. However, lack of integrated land use planning, irrigation water has been chronically polluted by industrial wastewater and urban sewage, resulting in agricultural land with high potential of heavy metal pollution. A novel screening approach to distinguish the agricultural lands with high potential of heavy metal pollution has been proposed. Massive surveyed data were transferred into Nemerow index for the all irrigation groups, the smallest unit of irrigation practice, for evaluation and mapping pollution levels through a geographic information system (GIS). Approximate 780,000 ha of agricultural land in Taiwan was quantified and classified by different pollution levels. Results showed that a total of 88 irrigation groups, covering 15,000 ha, identified as hazardous level, requires an urgent remediation action.

Keywords: Heavy metals, irrigation group, soil contamination

Environmental Forensics

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Pb Isotopic Techniques Application in Environmental Forensics

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Extended abstract

Heavy metal contaminations in soils pose a wide spectrum of problems, e.g., food crops safety and human health risk. Knowing only the total concentrations is not sufficient for contamination evaluation. Recent advances in isotope measurements help to decipher sources of pollution; further remedial action could be precisely taken. Techniques of high-precision lead (Pb) isotopic determinations by multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS) after chromatographic separation by Sr-spec resin in soil material were developed and applied to the farmlands pollution investigation in Wuri District, Taichung, where has been reported to produce Pb-contaminated brown rice. Pb concentrations in 15 cm topsoil of Wuri were detected from 24.6 to 1430 mg kg^{-1} in 2014, while EPA historical survey ranged from 14.6 to 10700 mg kg^{-1} within the whole contaminated sites. Meanwhile, The isotopic characteristics exhibited consistently within 2.440 - 2.441 ($^{208}Pb/^{207}Pb$) and 1.159 - 1.160 ($^{206}Pb/^{207}Pb$), far beyond the background characteristics, in spite of its varying corresponding Pb content of 95.5 - 1430 mg kg^{-1} at the contaminated site. This indicates an additional anthropogenic Pb source existed. The pollution suspect in Wuri had been identified as a single external source based on the consistence of Pb isotopic characteristics.

Keywords: Pb isotopes, soil contamination, environmental forensics

Remediation of Heavy Metals

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Remediation of Heavy Metals

Arsenic release and phytotoxicity to rice seedlings in As-contaminated paddy soils is increased by Si application

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Extended abstract

Silicon (Si) was shown to be able to reduce arsenic (As) uptake by rice in hydroponic culture or in low As soils using high Si application rates. However, the effect of Si application on As uptake of rice grown in As-contaminated soils using Si fertilizer recommendation rate has not been investigated. In this study, the effect of Si application using Si fertilizer recommendation rate on As release and phytotoxicity in soils with different properties and contents of As was examined. The results show that the concentrations of As in soil solutions increased after Si applications due to competitive adsorption between As and Si on soil solids and the Si concentrations in soil solutions were also elevated to beneficial levels for rice growth. The rice seedlings accumulated more As and its growth was inhibited by Si application in As contaminated/spiked soils. The results indicate that there is an initial aggravation in As toxicity before the beneficial effects of Si fertilizing to rice were revealed when Si application based on fertilizer recommend rate to As-contaminated paddy soils. Therefore, for As-contaminated paddy soils with high levels of As, the application of Si fertilizer could result in increasing As phytotoxicity and uptake by rice.

Keywords: Paddy rice, arsenic, Si fertilizer, As uptake, phytotoxicity

Effect of Cadmium on the Growth of a Potential Hyperaccumulator *Impatiens Walleriana* Grown Hydroponically

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Extended abstract

Impatiens (*Impatiens walleriana*) was evidenced as a potential cadmium (Cd) hyperaccumulator which accumulated more than 100 mg/kg in the shoots and its bioconcentration factor (BCF = ratio of plant conc. to soil conc.) and transfer factor (TF = ratio of shoot conc. to root conc.) were all than unity. Rooted cuttings of impatiens were hydroponically grown in the 100% MS solutions for 50 days artificially treated with different Cd concentrations (0, 2.5, and 5.0 M) to study the Cd effect on the growth exhibitions. Experimental results show that various organs accumulated high concentrations of Cd and the roots, stems, and leaves of impatiens accumulated 165-430, 190-225, and 95-105 mg/kg, respectively. Different Cd treatments affected the root length, leaf length, leaf width, leaf area, chlorophyll content, biomass, and the Cd accumulation of impatiens. However, the TF was not significantly affected by the Cd treatments and it was 1.1-1.4, 0.5-0.7, and 0.8-1.0 for stem, leaf and shoot, respectively.

Keywords: Bioconcentration factor (BCF), cadmium (Cd), impatiens, transfer factor (TF)

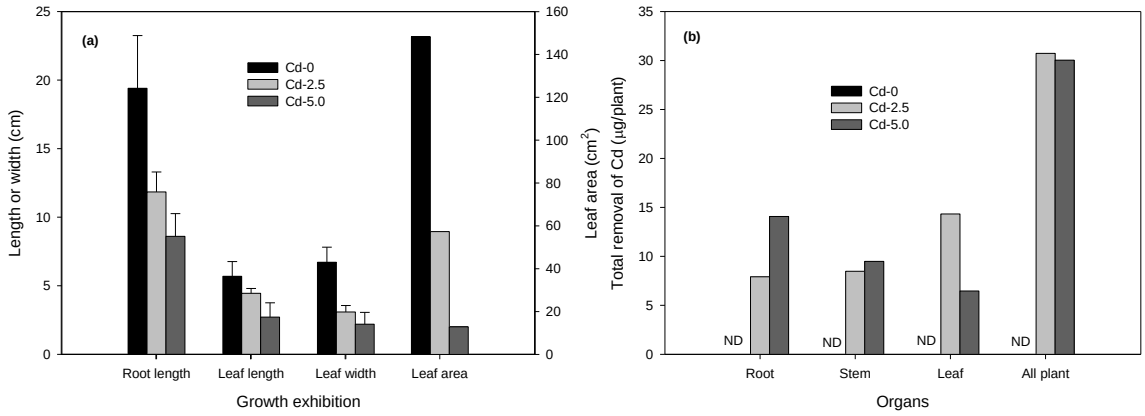

Figure 1. Effects of Cd treatments on the (a) various growth exhibitions and (b) total Cd removal of *Impatiens walleriana* grown hydroponically.

Characterization of Chromium in Contaminated Paddy Soil using X-ray Absorption Near Edge Structure (XANES) Spectroscopy

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Extended abstract

The contamination of Cr is particularly critical in the Changhua County, one of the major rice production sites in Taiwan. Although weathering of the indigenous Cr minerals, such as chromite ($FeCr_2O_4$), may account for the occurrence of Cr in natural soils, the majority of Cr found in the Changhua paddy soils is derived from the discharges of wastewaters from the industrial activities, such as electroplating, pigments, and leather manufacturing. Chromium has two predominant oxidation states in natural environments, Cr(VI) and Cr(III). While Cr(VI), occurred as chromate (CrO_4), poses a relatively high toxicity and mobility in ecosystems, the cationic Cr(III) easily precipitates and forms the insoluble $Cr(OH)_3$. Both Cr (III) and Cr(VI) can be preserved in the original minerals, co-precipitated with iron (Fe), aluminum (Al), and/or, manganese (Mn), adsorbed on surfaces of soil particles, and formed complex with dissolved organic and inorganic compounds. The bioavailability and mobility of Cr is controlled by the distribution of individual Cr species. That is, Cr species is subject to change along with environmental conditions, and thus, the characterization of Cr species other than total Cr amount is required to clarify and predicate the physiological and toxicological effects of Cr. The synchrotron-based X-ray absorption near edge structure (XANES) spectroscopy is a nondestructive and element-specific technique. XANES can probe all of the irradiated Cr atoms in a sample and determine directly their chemical forms. In this study, we aimed to characterize the Cr speciation using XANES spectroscopy as a complement of Tessier sequential extraction method. The linear combination fitting (LCF) for the Cr-XANES spectra indicated that Cr in the bulk sample was mainly dominated by Cr(III) sorbed on Fe hydroxides (Cr-FH), with lower concentrations of Cr(III) complexed with humic acid (Cr-HA) or in the bedrock (Cr-SPT). In addition to the increasing proportion of Cr-SPT in the bulk sample, the proportion of Cr-FH increased and the proportion of Cr-HA substantially decreased. These results provided us a better understanding of the distribution of Cr species in paddy soil. Furthermore, the characterization of Cr in complex matrices based on spectroscopic techniques may result in the advancement of environmental impact assessments for Cr-contaminated ecosystems.

Keywords: Chromium, XANES, speciation, paddy soil

The Mechanism of Arsenic Release in the Aquifer in Chiayi County, Taiwan

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Extended abstract

Arsenic (As) contamination in groundwater is a problem of environmental concern because As-containing drinking water possess serious risk to public health. In Taiwan, the arsenic contamination in groundwater mainly occurs naturally and is prevalent in South-western Taiwan, including Chiayi County. To understand the mechanism of As release from aquifer into groundwater in Chiayi area, Five monitoring wells were set up in Chiayi County to sample the groundwater from different depth in the range between 4 to 70 meter. The concentration and speciation of As were analyzed for the groundwater samples. In addition, groundwater samples were collected at dry- and wet-seasons to determine the potential contribution of As from percolation. Meanwhile, the bole-head samples were collected from a selected location in the same area and analyzed for the concentration and speciation of As. Figure 1(a) showed that As(V) was the predominant As species in the bole-head samples at different depths, while the concentrations of As(III) were minor. The concentrations of As in bole-head samples were found to vary along the sampling depths. The highest As concentrations occur in the groundwater samples collected at the depths of 6 and 49 meter. Unlike the As speciation results of the corresponding bole-head samples, As(III) was the predominant species in the groundwater samples of all depths. The redox potentials of groundwater were found to range from -100 to -150 mV, at which As(V) released from rock into groundwater could be reduced to As(III). Therefore, the released As concentration would increase with the sampling depth of the well. However, the results pointed out that at the depth around 40 meter the released arsenic concentration was at 50 ppb which was extreme lower than its adjacent depths. This was attributed to the low As concentration in the corresponding aquifer (40-50 m) compared to those at the other depths. The results of this study provided a direct evidence that the As in the groundwater in Chiayi County is released from the aquifer. The mineralogical compositions of As in the aquifers will be further analyzed using X-ray absorption spectroscopy.

Keywords: Arsenic (As); Groundwater; Aquifer; As speciation

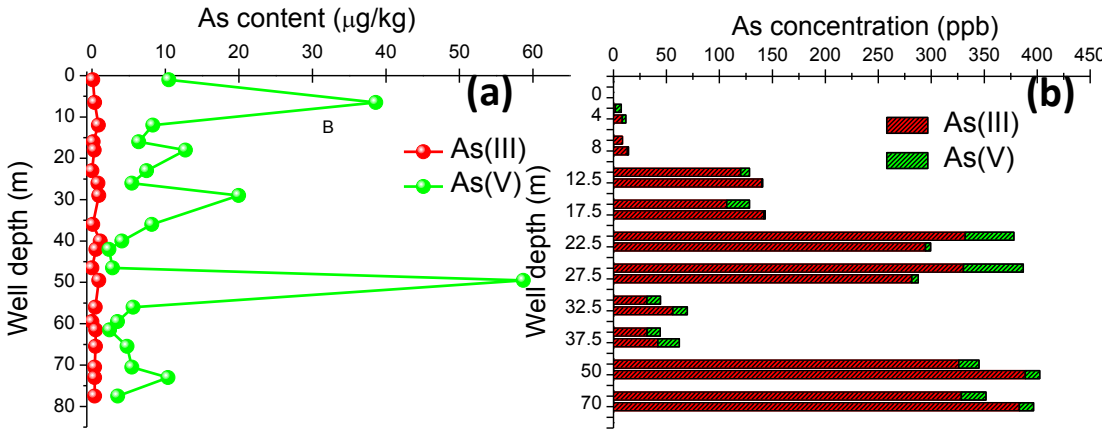

Figure 1. The concentrations and speciation of As in (a) the bole-head and (b) groundwater samples as a function of sampling depth.

Effect of Water Management and Soil Properties on Arsenic Accumulation in Paddy Rice

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Extended abstract

Water management has been demonstrated effective to reduce arsenic accumulation in paddy rice. In this study, four water management strategies were conducted to compare the effect on reducing arsenic accumulation in brown rice, they were: (1) Aerobic treatment for 10 days after 35 days of rice seedling (CK); (2) aerobic treatment for 3 weeks before rice heading (A); (3) aerobic treatment for 3 weeks after rice heading (B); and (4) aerobic treatment for 3 weeks before rice heading and continue for another 3 weeks after rice heading(C). Two soil series, Erlin (Eh) and Pinchen (Pc) were used in this experiment with two arsenic spiking levles for each (10 and 20 mg/kg for Erlin; 20 and 40 mg/kg for Pinchen). Soil redox potential raised about 60-400 mV during the aerobic treatment period. At the same time, As, Fe, and Mn concentrations of soil solution decreased significantly in Erlin soil, but not obviously in Pinchen soil. During the flooding period, As concentration of soil solution was not increased significantly in Pinchen soil. Considering the effects on reducing As concentration in brown rice, there was no significant difference among four water treatments in Erlin soil. In Pinchen soil with 40 mg/kg As spiked, As concentration of brown rice cultivated under strategy A (0.29 mg.kg) was significantly lower than those under strategy CK (0.42 mg/kg). Total As uptake of rice plant increased with the increasing As concentration in Pinchen soil. For rice cultivated in the As-spiked Erlin soil, As uptake decreased with the increasing soil As concentration. In addition to arsenic stress, a physiological mechanism may regulate the arsenic transport in rice plant. For rice cultivated in the Pinchen soil with 40 mg/kg arsenic spiked, available arsenic will enhance the As content of brown rice without inducing toxic effect on growing, and strategy A was practicable to reduce the risk of arsenic contamination in brown rice.

Keywords: Arsenic (As), water management, soil aerobic treatment, rice (*Oryza sativa* L.)

Table 1. Basic physical and chemical properties of the studied soils.

Soil	pH	Organic matter	Particle size			Fe_o‡	Al_o	Fe_d	Al_d	total As
		----------	sand	silt	clay	----------g/kg soil----------				mg/kg soil
Eh	7.64	22	392	403	205	3.37	0.75	9.34	0.77	8.13
Pc	6.43	11.5	182	374	444	5.05	2.25	42.7	5.37	10.8

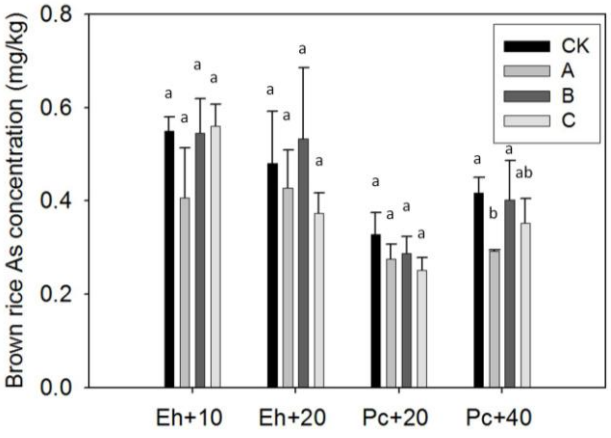

Figure 1. The arsenic concentration under four water managements in As-contaminated soils.

Amelioration of Heavy Metal Contaminated Agricultural Soil Using Different Amendments

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Extended abstract

Metal-contamination in agricultural soil in vicinity of mine-impact area is a continuous problem in worldwide. Chemical stabilization methods have been applied to reduce an adverse effect of heavy metals on all biota. Main objective of this research was to evaluate amelioration of different stabilizing amendment on reduction of toxic metal contents and change of chemical and biological properties in contaminated agricultural soil. Stabilizing amendment, organic and inorganic (alkali, mineral), were mixed with heavy metal contaminated agricultural soil samples. Change of heavy metal contents and soil properties was monitored during incubation (saturated soil paste, water contents 40%) period. During experimental period, As concentration in soil was lowered at the range of 15%-20%, 35%-50% and 50%-60% for alkali, organic, and mineral type, respectively, comparing to the control soil. However, As concentration in soil was increased when calcium superphosphate was applied. In case of Pb in soil, concentration was decreased at the range of 10%-100%, 35%-80% and 5%-75% for alkali, organic, and mineral type, respectively. Cation exchange capacity (CEC) in soil was increased 1 cmol(+)/kg - 23 cmol(+)/kg depending on varied treatment. Result showed that microbial populations in soil was increased compared to control ($2.0x10^{-5}$ CFU) after mixing with stabilizing amendment and order to organic type ($8.6x10^{-5}$ CFU) > mineral type ($8.0x10^{-5}$ CFU) > alkali type ($4.3x10^{-5}$ CFU). Furthermore, dehydrogenase activity in soil was averaged as 5.7 TPF mg/kg for alkali type and 23.5 TPF mg/kg for mineral type that all contents are higher than control (5.6 TPF mg/kg). Overall, application of stabilizing amendment in metal-contaminated agricultural soil is a feasible technique for reduction of contaminants and can be utilized in agricultural soil for remediation purpose.

Keywords: Dehydrogenase activity, Contaminated agricultural soil, Heavy metal, Stabilizing amendment, Microbial population

Efficiency of Soil Amendments for Stabilizing Heavy Metals in Soils Varied with Texture and Organic Matter Contents

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Extended abstract

Heavy metal pollution in agricultural field near at the abandoned metal mines is a critical problem in Korea. In order to remediate contaminated agricultural field, soil amendments are used. However, efficiency of soil amendments can be varied with different soil conditions. Therefore, main objective of this research was to evaluate efficiency of soil amendments for stabilizing heavy metals in different soil characteristics especially soil texture and soil organic matter contents. Total of 5 amendments, limestone (LS), calcium carbonate (CC), dolomite (DL), AMD sludge (AMDS) and steel slag (SS), were applied in heavy metal contaminated soil with fixed ratio(3%, w/w). Three different soil texture, silt loam, sandy loam, and loam, and contents of soil organic matter (1.5, 4.5, and 9%) were evaluated for heavy metal stabilization efficiency. Result showed that average concentration of Pb in soil extracted with 0.1N HCl was decreased to 99%, 97%, 83% for CC, LS, DL, respectively comparing to the control. In case of As, stabilization efficiency was ordered as AMDS (30%) ≥ LS (29%) > CC (18%) ≥ DL (17%) > SS (-1%) in soil. In terms of soil texture, sandy loam showed the highest efficiency for Cd stabilization when applying AMDS (26%) and DL(33%) comparing to other amendments. Also, the highest efficiency of Cd(32%) and Pb(63%) was observed when 9% of soil organic matter was applied in cooperation with AMDS. In conclusion, soil amendments can be applied in heavy metal contaminated agricultural field and soil condition such as soil texture and organic matter contents should be considered to evaluate heavy metal stabilization efficiency.

Keywords: Calcium carbonate, Heavy metal, Limestone, Soil texture, Soil organic matter

Evaluating Feasibility of Coal Combustion Product (CCP) for Revegetation in Coal Mine Area

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Extended abstract

Coal ash (CA) is a by-product from the thermal power plants and contained nutrients such as Ca, Mg, and other inorganic ions. Also, alkaline characteristics of CA can be applied to stabilize acidic conditi on of wastewater and coal mine waste. For this reason, main purpose of this study was to evaluate the possibility of coal ash as a material for stabilization of the wastewater and for the adoption of vegetati on coverage in coal mine. Total of 14 different treatments were constructed with a mixture of coal ash and mine waste in Hwasun coal mine area. Leachate samples were collected every month and monitor ed for chemical properties (pH, EC, heavy metals, inorganic ions). In addition, vegetation coverage wa s evaluated with Wincam program. The results showed that pH of leachate in coal ash treatments were increased from 6.2 to 8.14 within first two months (control: from 5.64 to 5.82). Also, heavy metal con centration such as As, Cd, Cu, Pb, Zn was at the range of BDL (below detection limit) - 2.11 mg/L in t he leachate. In terms of inorganic concentration, concentration of Ca was at the range of 1.17 mg/L to 78.94 mg/L and 0.16 mg/L to 131.85 mg/L for Mg that is much higher than the control. Consequently, much higher vegetation coverage (36 – 42%) was observed in CA treatment comparing to control (8. 0 – 8.5%). In conclusion, coal ash can be applied to stabilize the mine waste and used as cover materia l for vegetation.

Keywords: Best management practice, Coal combustion product, Coal mine, Vegetation

Human Health Risk Assessment from Exposure to Arsenic in The Abandoned Tin Mine in Thailand

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Extended Abstract

An abandoned tin mine situated in the Northern region of Thailand has been ranked as one of the highest scores using a Hazard Ranking System Quickscore concerning surface water migrations, groundwater migrations, soil exposure pathways and air migration. Surface water, sediments, groundwater and soil samples were collected to delineate the extent of contamination. Arsenic was identified to be the most problematic heavy metals found in the area. The Surface water samples from the river nearby were below detection limits. Arsenic concentrations in sediments were higher downstream than that of upstream, 52-434 mg/kg, which were at the levels toxic to benthic organisms. However, arsenic concentrations in groundwater upstream and downstream were at or below the groundwater standard of 0.01 mg/l. The levels of arsenic concentrations in soils samples at the depth of < 30 cm were approximately 21 and 166 mg/kg (Fig.1), resulting in the total (oral and dermal) Hazard Quotients (HQ) of 0.1235 and 0.922 and the total cancer risk were 2.49 $x10^{-6}$ and $1.9x10^{-5}$ in the residential areas outside the mining boundary and inside the mining boundary. The total (oral and dermal) cancer risks for adults working in the historic sedimentation pond agricultural areas for 25 years with the arsenic concentration of 357 mg/kg were $3.06x10^{-4}$ and 3.2×10^{-5} respectively, whereas the HQ for oral and dermal exposure was 1.58 and 0.082 respectively.

Keywords: Arsenic (As), Tin Mine, Abandoned Mine, Risk Assessment

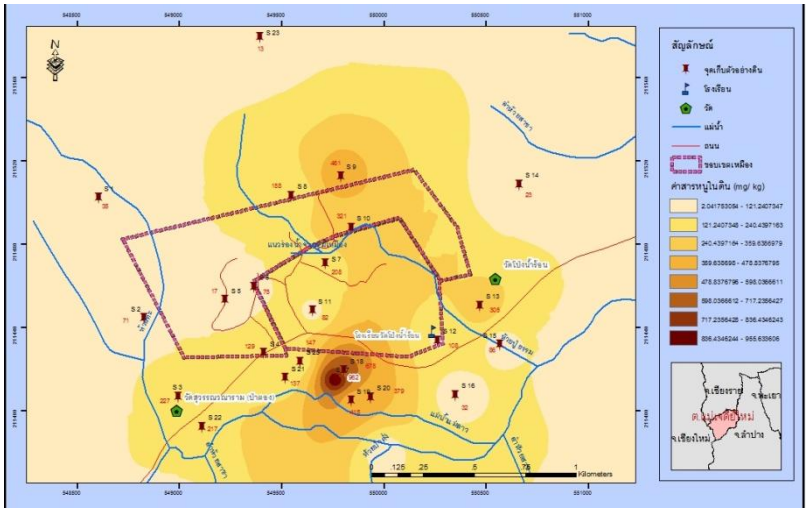

Fig. 1: Distribution of Arsenic contamination in soil samples.

Table 1. Arsenic concentrations in soil samples, hazard quotient and cancer risk in three types of areas.

Soil Samples	**outside the mining boundary**	**inside the mining boundary**	**historic sedimentation ponds**
Arsenic conc. in soil samples (mg/kg)	21	166	357
Hazard Quotient-oral	0.1187	0.884	1.58
Hazard Quotient-dermal	0.0048	0.038	0.082
Cancer Risk-oral	2.158×10^{-5}	1.7×10^{-4}	3.06×10^{-4}
Cancer Risk-dermal	2.28×10^{-6}	1.8×10^{-5}	3.23×10^{-5}
Total Hazard Quotient	0.1235	0.922	1.662
Total Cancer Risk	2.49×10^{-6}	1.97×10^{-5}	3.536×10^{-5}

Stabilization of Heavy Metals with Industrial By-products in Agricultural Field

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Extended abstract

Various remediation technologies have been applied to restore heavy metal contaminated agricultural field. Among different remediation technologies, chemical stabilization technique has been widely applied in agricultural fields due to the minimal adverse impact on the soil fertility and cost-effectiveness. The main purpose of this study was to monitor stabilization efficiency of heavy metals in agricultural field using various industrial by-products. Applied by-products were limestone (LS), Steel slag (SS) and acid mine drainage sludge (AMDS) with fixed mixing ratio of 3% (w/w) in field. Concentration heavy metals including As was monitored using acid extraction methods (As-1M HCl, heavy metal-0.1M HCl) for 52 weeks. Results showed that the highest stabilization efficiency for As (58% of reduction) was observed when AMDS was applied. On the other hand, increase of arsenic concentration was monitored in SS treatment. In the case of Cd, Pb and Zn, LS showed the highest efficiency for heavy metal decreasing as 45%, 98% and 47% respectively. In addition, heavy metal concentration in soil solution was also decreased at the range of 44 – 93% depending on heavy metal species and applied by-products. Overall, industrial by-product can be utilized for heavy metal stabilization and reduction of bioavailable fraction of heavy metals in soil.

Keywords: Arsenic, Bioavailability, By-products, Heavy metal, Stabilization

Bioremediation

Effect of Compost Maturity on the Solubility Enhancing Effect on PCE and Toluene

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Extended abstract

The structure variation of three bagasse-derived compost samples were examined during their maturation process. The surface tension and dissolved organic carbon content of their extract (compost tea) were measured, and their aqueous solubility enhancement of tetrachloroethene (PCE) and toluene were examined. The ^{13}C NMR results showed that the alkyl and aromatic contents of the investigated composts increased as the composting time increased from 0 to 6 months, and the dissolved organic carbon content decreased with composting time. Although 0-month sample had the largest dissolved carbon content among three test samples, its surface tension reduction effect was the smallest, and thus had the least solubility enhancement effect on PCE and toluene. The extraction of 3-month compost sample showed the strongest surface tension reduction effect, in addition to its high alkyl- and O/N-alkyl-C content, so the 1-month compost tea had the strongest solubility enhancement effect on PCE. Among the three tested samples, the 6-month compost tea contained the strongest aromatic structure. Therefore, despite to its smallest dissolved organic carbon content, the 6-month compost tea still exhibited the most strong solubility enhancement effect on toluene. Overall, this study suggested that compost tea could act as effective biosurfactant to enhance the aqueous solubility of PCE and toluene.

Keywords: Biosurfactant, Compost Maturity, Dissolved Organic Matter, Solubility Enhancement

Table. Relative distribution of ^{13}C NMR spectroscopy of compost samples

Sample	Chemical shift regions			
	Alkyl-C (%)	O/N-Alkyl-C (%)	Aryl-C (%)	Carboxyl-C (%)
0-month sample	27	49	15	9
3-month sample	31	39	19	11
6-month sample	35	36	22	7

(a) (b)

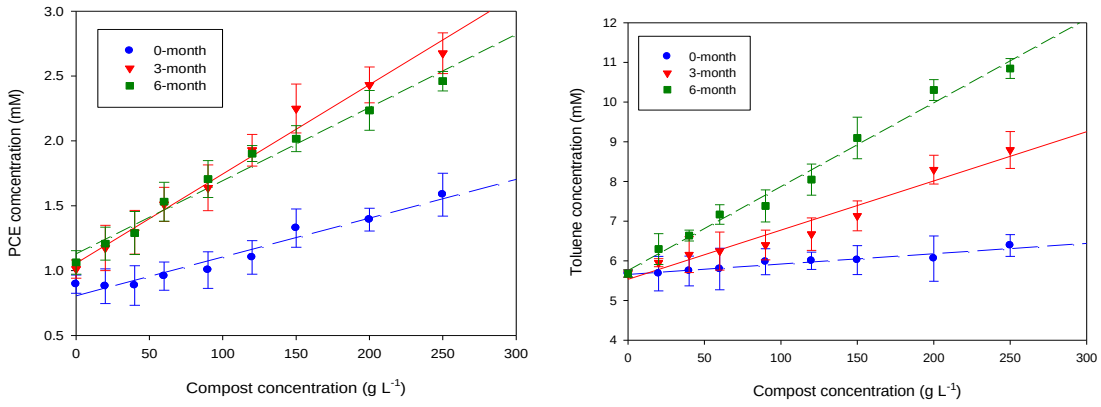

Figure 1.Solubility of (a) PCE and (b) toluene by three aqueous compost samples

In situ aerobic bioremediation technologies for treatment of gasoline constituents from the leaking petrol stations and strategies to enhance process efficiency

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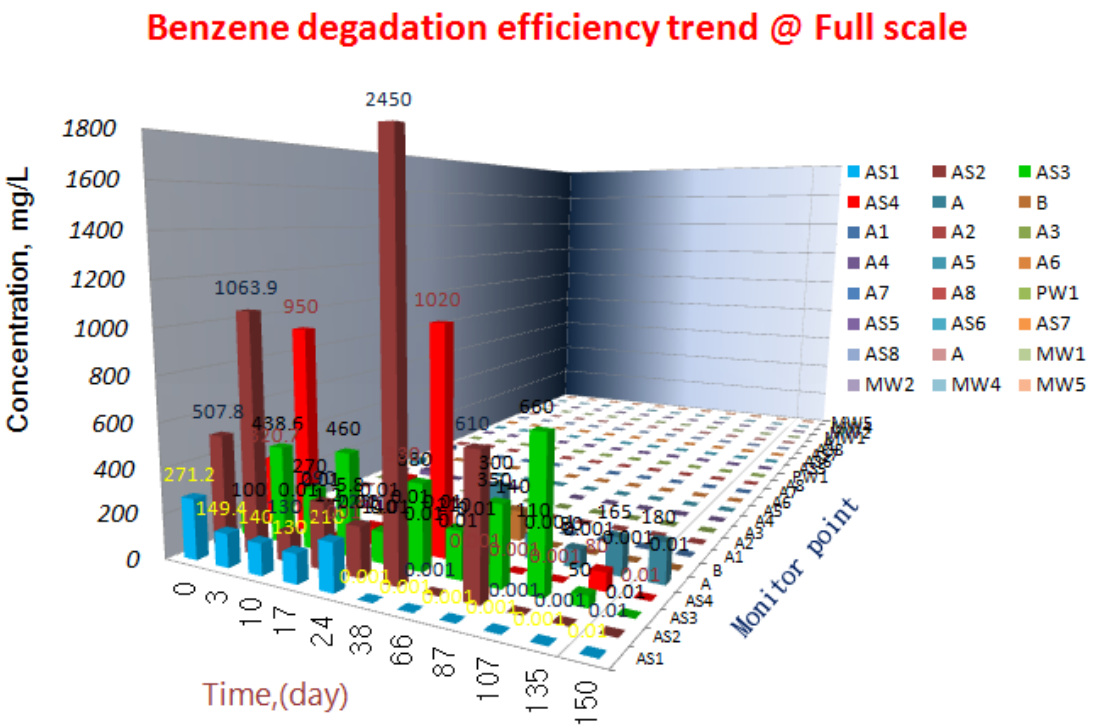
Extended abstract

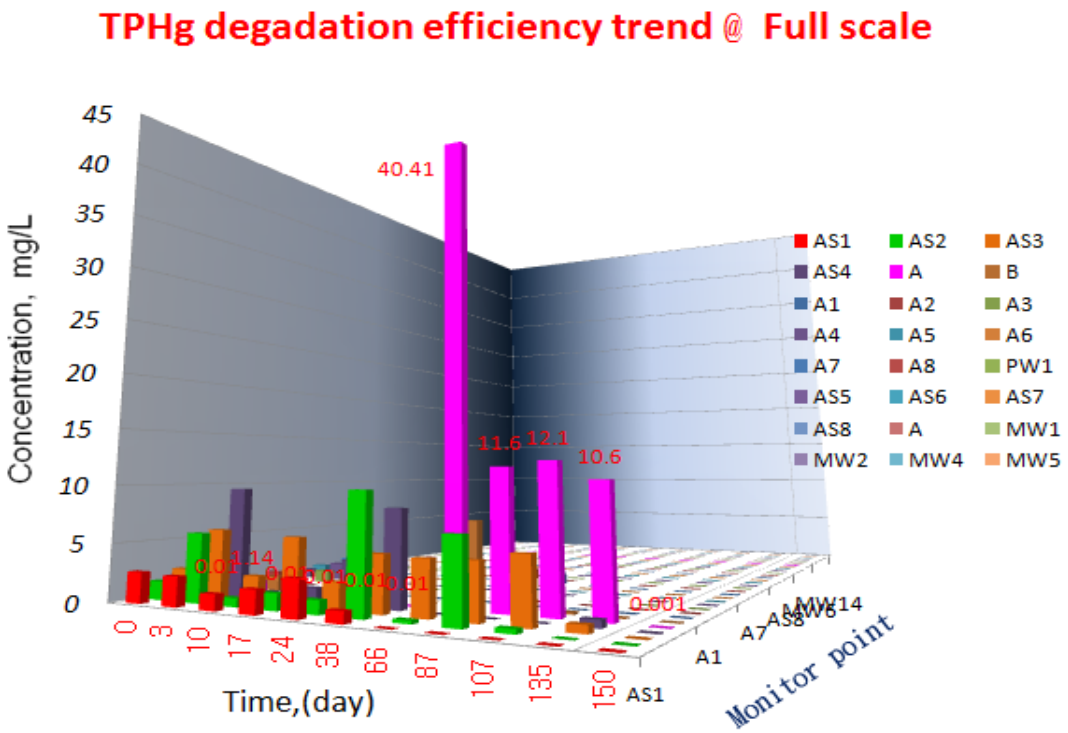
A number of methods are available for the ***in_situ*** bioremediation of gasoline constituents from the leaking petrol stations that are susceptible to enhanced aerobic biodegradation. Oxygen is considered by many to be the primary growth-limiting factor for hydrocarbon-degrading bacteria, but oxygen is normally depleted in zones that have been contaminated with residual hydrocarbons. The popular solutions are available to do this accelerate the effectives in reducing levels of the target contaminants at leaking sites in the capillary fringe or saturated zone without dig and dump, chemical oxidation or mechanical aeration [e.g., biosparging, bioventing, oxygen infusion(for example, oxygen releasing compounds (ORC) or pure oxygen gas addition, hydrogen peroxide or high-oxygenated water injection), and electrolytic oxygenation (using electrolysis to split oxygen molecules from water）]. The study focuses on the ***in_situ*** aerobic bioremediation of contaminated soil and groundwater in the presence of high-oxygenated water and nutrients, the process of stimulating indigenous oxygen-dependent microorganisms. The effective decontamination parameters are investigated in the sequential experiments. Laboratory- and full-scale experiments are conducted on a number of different target compounds of site-specific conditions. The results indicate：(Ⅰ) the degradation efficiency ranked as Benzene＞Toluene＞EthylBenzene＝Xylene(s)＞Naphthalene＞Tri-Methyl Benzene(TMB)＞Methyl tert-butyl ether(MTBE) under laboratory conditions, (Ⅱ) MTBE in high-oxygenated water conditions is degraded slowly, it is likely to be recalcitrant to anaerobic biodegradation. (Ⅲ) Field demonstration of MTBE degradation is also inconsistent, potentially presenting the rare situation of a compound specific biological degradation capacity being highly variable amongst geographically diverse consortia of similar species. (Ⅳ) Two full-scale tests of bio-stimulation have been performed in the field. (Ⅳ-A) Site A is using the pump to distribute the high-oxygenated water and modifiers directly to the vadose zone periodically. This experiment is conducted for 150 days. More than 20 groundwater monitoring wells in total have been installed above the plume since 2008. The average dissolved oxygen is 2.25 ppm, pH is 6.85, and the temperature is 26.7℃. Within fifty weeks Benzene concentration is reduced from 2450 to 50 μg/L. There has been a slight rebound to 180μg/L. Total petroleum hydrocarbons(TPHs) in groundwater is reduced from 40.01 to 0.001 mg/L. (Ⅳ-B) Site B is adding the high-oxygenated water and modifiers, about 18,420L at 3~4 day intervals for 125days, and the all gradients are distributed by gravity to the depth of 6~7 meters. The concentration of Benzene in groundwater is reduced from 1.072 mg/L to the below detection limit (≦0.0002 mg/L), and TPHs in soil is reduced from 2,020 to 9.37 mg/Kg.

Keywords: ***in_situ*** bioremediation, full-scale experiment, bio-stimulation, high-oxygenated water

Figure



Figure



Bio-stimulation of oil-contaminated groundwater with mixed consortia under the high-oxygenated water and bio-surfactant applied conditions

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Extended abstract

The study is used to accelerate naturally occurring ***in_situ*** bioremediation of petroleum hydrocarbons that are susceptible to enhanced aerobic biodegradation. In a similar way to ex-situ soil treatment, it is required to uniformly distribute oxygen and nutrients within the treatment zone. When the performance of ***in_situ*** bioremediation is limited, it is suitable for as a polishing tool following a more aggressive technique such as mixed consortia addition [e.g., high-oxygenated water, nutrients and bio-surfactant]. Most, but not all, enhanced aerobic bioremediation technologies primarily address petroleum hydrocarbons and some oxygenates that are dissolved in groundwater or are sorbed to aquifer material in the capillary fringe or saturated zone. Additionally, desorption/dissolution of contamination trapped in soil is one of the major mechanisms that dictate the overall contaminant removal efficiency. The results indicate there is a positive relationship between the rate of petroleum hydrocarbons biodegradation and presence of the bio-surfactant and high-oxygenated water alone or in combination. The biodegradation data fit well to first-order kinetic model, after 260 days of simulation and analysis, the first order kinetics are obtained, half-life times ($t_{1/2}$) and the kinetic constants (K, Day^{-1}) are determined. The models reveal that the combination of high-oxygenated water, nutrients and bio-surfactant have higher biodegradation rate constants (k) as well as lower half-life times ($t_{1/2}$) than the control system (without surfactant or high-oxygenated water). The scheme presents hydrocarbon removal efficiencies of >91 % with higher initial concentrations of the aromatic compounds in groundwater about 5.0~50.0 mg/L. An increase in the microbial activity by 12.1 fold in Bacteria growth from 3.02×10^5 to 3.67×10^6 cfu/g is achieved in the designed system amended with modifier. This process is inexpensive, efficient, technical ability and environmentally friendly, and may thus offer a greater choice for oil-contaminated site remediation

Keywords: bio-surfactant, bio-stimulation, high-oxygenated water, first-order kinetic model, half-life

Degradation of Trichloroethylene Using Iron-coated Granular Graphite

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Extended abstract

This study evaluates the efficiency of trichloroethylene (TCE) degradation with a composite material, which was manufactured by coating iron on the surface of granular graphite. The composite material has the following advantages when used as the filling material in a permeable reactive barrier: be able to adsorb TCE, be able to degrade the adsorbed TCE, and provide large porosity for groundwater flow. The coating of iron on the granular graphite was tested with two different methods: one by coating under high temperature and the other one by electrochemical plating. The results indicated electrochemical plating is more efficient than high temperature coating based on the amount of iron coasted per unit mass of graphite. The structure of the composite material was evaluated with scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). The TCE degradation efficiency was evaluated by mixing the composite material with 10-ppm TCE solution in serum bottles. The total TCE mass in the solution as well as the composite material was extracted with a head-space extractor and analyzed with gas chromatography equipped with a mass selective detector (GS-MS). The factors evaluated were the material and pH. The SEM and EDS results indicate the iron was evenly distributed on the surface of the granular graphite. The coating of iron increased the surface area of the granular graphite. The amount of added surface area increases with the electrochemical plating time. The TCE degradation results show the composite material is able to degrade TCE, whereas granular graphite alone is unable to degrade TCE. The TCE degradation efficiency decreases with pH, suggesting acidic condition is favorable for TCE degradation. The kinetic analysis shows the degradation reaction to be pseudo-first-order. The reaction rate constant was normalized with respect to the mass of iron per unit volume of solution. The value is higher than those found in the literature, indicating the composite material is more efficient in degrading TCE than pure zero-valent iron. This suggests the composite material of this study has the potential to be used as the filling material of permeable reactive barriers.

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The Working Group on Remediation for Soil and
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