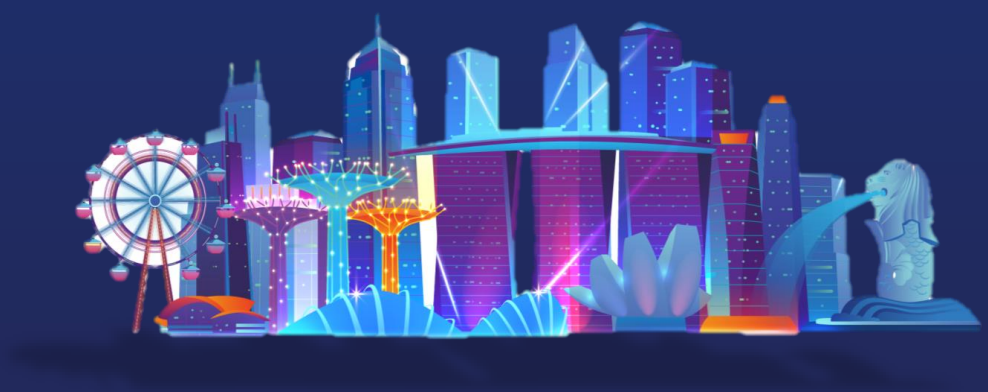
2023 Global ESG Forum in Singapore

Pursuing Sustainability through ESG

June 26(MON) ~ **29**(THU), **2023** | **CREATE, Singapore**

PROCEEDING BOOK



International ESG Association
KOREA UNIVERSITY
ESG 연구원 ESG Research Institute
APRU Sustainable Waste Management
E2S2 CREATE
NUS National University of Singapore
NUS BUSINESS SCHOOL

FOCAL POINT ON ENVIRONMENTAL, SOCIAL AND GOVERNANCE INITIATIVES
PRODUCED IN PARTNERSHIP WITH THE INTERNATIONAL ESG ASSOCIATION

MAKING UP FOR LOST TIME

South Korea is working hard to set standards in A WILD ESG RATINGS MARKETPLACE.

"In terms of ESG management, South Korea was a late follower," says Jay Hyuk Rhee, a professor at the school of business at Korea University in Seoul, "But, now — most, if not all, South Korean corporations take ESG management very seriously."

Environmental, Social, and Governance (ESG) ratings are being increasingly taken into account, not only by people seeking to make socially conscious investment decisions, but also by consumers and prospective employees.

ESG ratings provide information about a company's sustainability status based on three categories: the environment, social issues, and governance. This includes factors such as climate policies, waste production, energy consumption, workplace conditions, diversity and inclusion, and business ethics — elements that have a financial impact, but are not usually captured in a typical financial analysis.

While South Korea was late to the table — only introducing incentives to adopt ESG global standards in January 2021, following pressure from both consumers and Western companies they supplied goods to — it has created guidelines to gain a more objective and transparent view of these scores that inform investments across assets valued at more than US$37.8 trillion.

THE ESG RATINGS LANDSCAPE

Worldwide, there are at least 140 companies that calculate ESG ratings,

A retention pond polluted by runoff from landfill. Waste management is one of the key factors considered in ESG ratings.

1

ESG ratings calculate a company's score based on a set of **ENVIRONMENTAL, SOCIAL, AND GOVERNANCE** indicators.

2

There are currently **MORE THAN 140 COMPANIES** that calculate ESG ratings.

and this number is likely to grow, with the ESG data market projected to exceed US$1.3 billion during 2022. These ratings are largely unregulated, and each provider has their own model for calculating them, however, the specific indicators used typically remain concealed in order for companies to protect their intellectual property. This situation often results in wildly different scores for the same company based solely on the ESG rating provider chosen.

"It's very difficult to achieve a consistent result across different ESG rating agencies," affirms Rhee. And without consistency and objective indicators of where firms can improve their ESG practices, it's difficult for companies to make changes for the better.

Rhee's colleague, Yong Sik Ok is an environmental scientist and the programme director of the Association of Pacific Rim Universities (APRU) Sustainable Waste Management Program, who is also based at Korea University. This lack of transparency and consistency prompted Rhee, Ok and a team of experts — including representatives from the Korea Productivity Center and the Korea Society of Strategic Management, in collaboration with South Korea's Ministry of Trade, Industry and Energy (MOTIE) — to develop a free to access, open, transparent representation from 13 major South Korean and global evaluation and information disclosure agencies. They called this the K-ESG guidelines.

"They reflect the core issues of global ESG standards," says Rhee. "Corporations can see their current status and examine their progress in terms of KPIs including such things as carbon emissions and plastic waste reduction."

PLASTIC WASHING

However, there's always a way for companies to game the system, especially when there are billions of investment dollars at stake. Greenwashing refers to the promotion of misleading information suggesting that products or investments are more environmentally sound or "green" than they really are.

In the case of ESG ratings, greenwashing, or perhaps most aptly, 'plastic washing' is rampant. "Plastic waste is generated in high amounts everywhere, and greenwashing is done by many corporations for plastic waste," says Ok. He cites a major soft drink manufacturer as an example — many millions of dollars were spent promoting the claim that their bottles are made of marine plastic waste, but at the same time it was never said that the company is among the world's biggest plastic polluters.

It's a problem that is set to grow — globally, approximately 400 million tonnes of plastic waste is produced every year, if nothing changes this is expected to double by 2040. "While the United Nations declared new plastic-related regulations to take effect in 2024, it's essential to standardize these regulations globally," says Ok.

As ESG ratings are largely unregulated, and are typically based on companies' public-facing ESG disclosures, the potential for greenwashing or plastic-washing is high. Regulatory groups worldwide, such as the UK's Financial Conduct Authority (FCA) and the International Regulatory Strategy Group (IRSG), and the European Commission are now looking into the ESG ratings market and whether policy may be introduced.

South Korea has the opportunity to be a leader in this space. "In terms of ESG management, South Korea has always followed the rules set by the EU and the US. Through K-ESG, we hope to become a rule-setter," says Rhee. ■

3

ESG assets are projected to exceed **US$50 TRILLION** by 2025.

Jay Hyuk Rhee is the co-president of the **INTERNATIONAL ESG ASSOCIATION**.

"In terms of ESG management, South Korea has always followed the rules set by the EU and the US. Through K-ESG, we hope to become a rule-setter."

MEASURING ESG IN SOUTH KOREA

South Korea's Ministry of Trade, Industry and Energy has **RELEASED GUIDELINES** that make it easier for domestic companies to assess their own ESG performance.

In recent years, many ESG rating agencies have been established worldwide to guide investors as to where their money is best spent. They use environment-, social-, and governance-related indicators to measure a company's sustainability.

"It is no longer enough for investors to see that a company is making big money," explains Jay Hyuk Rhee, professor of business administration at Korea University in Seoul. Consumers are looking for environmentally conscious companies, while robust governance structures are necessary for their future sustainability.

But the ESG rating landscape can be confusing. Agencies use a variety of evaluation methods and emphasize different indicators, of which there are thousands. This often makes it difficult for companies to understand why they have been given a certain rating or what they can do to improve their ESG measures. "There have been a lot of complaints from South Korean companies," says Rhee.

To address this, South Korea's Ministry of Trade, Industry and Energy (MOTIE) released its K-ESG guidelines on 1 December 2021 as part of the government's ESG Infrastructure Expansion Plan. The guidelines provide transparent and detailed criteria to empower companies to evaluate their own ESG performance.

Over three years, Rhee led a team of experts, including representatives from the Korea Productivity Center and the Korea Society of Strategic Management, and consulted with ESG-related government offices, to analyse more than 3,000 ESG indicators and measurement criteria from 13 major South Korean and global evaluation and information disclosure agencies. The analyses led to the consolidation of 61 core indicators that comply with global ESG standards.

The indicators are spread over the expected categories of environment, social and governance measures; but also include five indicators related to information disclosure.

The K-ESG environment indicators include items related to eco-label certifications, implementation of environmental laws, greenhouse gas emissions, waste and pollutant production and recycling rates. The social indicators measure things like socially responsible management practices, industrial safety and diversity in the workforce. Finally, there are 17 governance indicators related to board composition, shareholder rights, auditing and ethical management.

Each indicator is explained in detail, with resources provided to help organizations evaluate their performance and implement more ESG-compliant practices.

Rhee stresses that the K-ESG guidelines reflect the core issues of global ESG standards. "If South Korean corporations score well with these guidelines, they will be well evaluated by rating agencies," he says.

They also make it easier for companies to self-assess, giving them an opportunity to adjust their systems and improve their sustainability.

▲ **Greenhouse gas emissions are one of the indicators included in the K-ESG guidelines released by MOTIE, South Korea in December 2021.**

In May 2022, Yoon Suk-yeol's presidential transition committee announced it would take on 110 national tasks that are largely focused on revitalising the country's economy. One task, supervised by MOTIE, will aim to promote sustainable growth, business growth and expansion of social value-linked models, including ESG.

Rhee expects the new administration will work on improving the K-ESG guidelines and developing specific criteria for companies in different sectors and for small- and medium-sized enterprises.

"We have a new era of ESG practices in South Korea," says Rhee. "There will be big opportunities for corporations that are willing to pay attention to and become leaders." ■

Ministry of Trade, Industry and Energy

english.motie.go.kr/

Contents

Overview

Title:

2023 Global ESG Forum

Theme:

Pursuing Sustainability through ESG

Date:

26th June (Mon.) ~ 29th June (Thu.) 2023

Venue:

CREATE, Singapore

List of Participating Organizations

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广东省科学院
GUANGDONG ACADEMY OF SCIENCES

University of Glasgow

香港浸會大學
HONG KONG BAPTIST UNIVERSITY

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

홍익대학교
HONGIK UNIVERSITY

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

香港珠海學院
HONG KONG CHU HAI COLLEGE

河北工業大学
HEBEI UNIVERSITY OF TECHNOLOGY

JAMES COOK UNIVERSITY AUSTRALIA

UNIVERSITI KEBANGSAAN MALAYSIA
The National University of Malaysia

KYUNG HEE UNIVERSITY

KRICT Korea Research Institute of Chemical Technology

KAGS 한국국정관리학회
The Korean Association for Governance Studies

KNU KYUNGPOOK NATIONAL UNIVERSITY

KMU 국민대학교
KOOKMIN UNIVERSITY

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

NUS National University of Singapore

NUS National University of Singapore | NUS BUSINESS SCHOOL

南開大學
Nankai University

UNIVERSITI MALAYSIA TERENGGANU

UNIVERSITI MALAYA

OJEong Resilience Institute
OJERI @ KU

Mineral and Energy Economy Research Institute
Polish Academy of Sciences

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Soongsil University

SUSS
SINGAPORE UNIVERSITY OF SOCIAL SCIENCES

List of Participating Organizations

SEOUL NATIONAL UNIVERSITY

SHANGHAI JIAO TONG UNIVERSITY

UMCS
MARIA CURIE-SKLODOWSKA UNIVERSITY IN LUBLIN

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

浙江大學
ZHEJIANG UNIVERSITY

KBPA 한국바이오플라스틱협회
Korean Bioplastics Association

Est.1991
INDUSTRIAL
INNOVATION
GROUP

ELLEN MACARTHUR FOUNDATION

Welcome Message

Welcome to the 2023 Global ESG Forum in Singapore, organized by the International ESG Association (IESGA). The IESGA firmly believes that comprehensive monitoring of corporate business activities based on non-financial indicators, encompassing environmental (E), social (S), and governance (G) factors, holds paramount importance for enhancing corporate sustainability in the future. Therefore, it is imperative for Korean companies to transition from passive compliance with existing ESG regulations to becoming proactive leaders in new ESG initiatives.

Given the prolonged pandemic, there is a growing concern regarding corporate sustainability, and the wave of corporate restructuring is significantly impacting employees, business partners, and local communities. Conversely, companies like Amazon, which have thrived during this crisis, are experiencing an unprecedented financial boom. Nevertheless, a group of U.S. business managers has declared a stakeholder capitalism approach, highlighting the need to consider a broader range of stakeholders, inclusive growth, and long-term shareholder value rather than short-term gains. While the primary purpose of a business is profit generation, relying solely on financial performance to determine sustainability is no longer feasible. Any company that violates procedural fairness or lacks social legitimacy will face societal rejection, irrespective of financial success. This shift in social perception has led to the emergence of ESG management, emphasizing the urgent need to comprehensively evaluate business activities based on non-financial criteria (i.e., ESG) in order to improve corporate sustainability. Implementing ESG management poses challenges as the E, S, and G aspects are highly interconnected, and it is practically impossible to identify all the individual issues falling under each category. Nevertheless, universally adopted ESG evaluation measures do exist. Many companies, especially large conglomerates, are diligently responding to these globally recognized ESG indicators. The question arises: how will global ESG indicators evolve in the future? While the existing global ESG evaluation indicators were established through various initiatives, the number of evaluation items will increase, and stricter criteria will eventually be adopted. Companies that choose to wait for new evaluation indicators to emerge, hoping for easier compliance, will inevitably lag behind. It is crucial for companies to move away from a passive approach of conforming to existing rules and take an active role in establishing new ESG standards.

In light of these considerations, the aim of the Global ESG Forum is to establish a global knowledge network comprising ESG scholars and practitioners. It aims to provide a platform for collective intelligence on the current and future landscape of ESG management for companies in the ESG era. In 2022, the IESGA successfully hosted the inaugural Global ESG Forum from August 28 to 31, in Korea. The four-day event, supported by around 60 experts from nine different organizing committees, was one of the largest ESG forums in the country. In 2023, we are excited to visit Singapore, where we will examine corporate ESG trends and expand our global network. We will engage in in-depth discussions on the future of ESG management for companies in the ESG era. The 2023 Global ESG Forum will take place in Singapore from June 26 to 29, 2023 (Monday–Thursday), bringing together participants not only from Singapore and Korea but also representatives and scholars from global companies, embassies, major universities, and corporate research institutes worldwide.

We extend a sincere invitation to you, as a prominent leader spearheading ESG initiatives, to grace the 2023 Global ESG Forum with your presence. Your participation would be a privilege, and we hope that you will find time in your busy schedule to attend and share valuable insights with global leaders.

Prof. Yong Sik Ok

President

2023 Global ESG Forum

Prof. Jay Hyuk Rhee

President

2023 Global ESG Forum

Organizing Committee

Yong Sik Ok

President, International ESG Association, Republic of Korea
Professor, Division of Environmental Science and Ecological Engineering, Korea University, Republic of Korea
Chair and Program Director, Association of Pacific Rim Universities Sustainable Waste Management (APRU SWM)
2022 Highly Cited Researcher
(Environment and Ecology, Engineering, and Biology and Biochemistry)

Jay Hyuk Rhee

President, International ESG Association, Republic of Korea
Professor, School of Business Administration, Korea University, Republic of Korea
Director, Korea University ESG Research Institute, Republic of Korea

Yoon-Dae Euh

Former President, Korea University, Republic of Korea
Former Chairman, Presidential Council on Nation Branding, Republic of Korea
Former Chairman, KB Financial Group, Republic of Korea

Lawrence Loh

Director, Center for Governance & Sustainability,
Business School, National University of Singapore, Singapore
Professor, Business School, National University of Singapore, Singapore

Sung Yeon Hwang

Professor, Department of Plant & Environmental New Resources, Kyung Hee University, Republic of Korea

Program Overview

<table>
<tr><th>Time</th><th>26th June</th><th>27th June
(Day 1)</th><th colspan="2">28th June
(Day 2)</th><th colspan="2">29th June
(Day 3)</th><th>30th June</th></tr>
<tr><td>Venue</td><td></td><td>Main Hall</td><td>Main Hall</td><td>Medium Hall</td><td>Main Hall</td><td>Medium Hall</td><td rowspan="2">Technical Tour
*Invited Only</td></tr>
<tr><td>09:00
~
09:30</td><td rowspan="9"></td><td rowspan="2">Registration & Networking Coffee</td><td colspan="4"></td></tr>
<tr><td>09:30
~
10:00</td><td colspan="4" rowspan="2">Registration & Networking Coffee</td></tr>
<tr><td>10:00
~
10:30</td><td rowspan="3">Opening Session I</td></tr>
<tr><td>10:30
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14:00</td><td>Battery Metals and Recycling</td><td>Net Zero & Renewable Energy</td><td>Voluntary Carbon Market (VCM): Carbon Negative & Biochar</td><td>Innovations in Sustainable Environmental Practices</td><td rowspan="3"></td></tr>
<tr><td colspan="5">Lunch & Interactive Session</td></tr>
<tr><td>14:00
~
18:00</td><td>BlackRock Special Session</td><td rowspan="3">Sustainable Plastic Management</td><td>Net Zero & Renewable Energy</td><td>ESG from Consumers' Perspective (Korea session)</td><td></td></tr>
<tr><td>S&P Global Special Session</td><td rowspan="2">ESG Overview</td><td colspan="2" rowspan="2">Technical Tour
*Invited Only</td></tr>
<tr><td>Opening Session II</td></tr>
<tr><td>18:00
~
20:00</td><td>Welcome Dinner
*Invited Only</td><td></td><td></td><td></td><td colspan="2">Farewell Dinner
*Invited Only</td></tr>
</table>

Welcome & Farewell Banquet

Banquet	Date	Time
Welcome Dinner	26th June	18:00 – 20:00
Farewell Dinner	29th June	18:00 – 20:00

Venue:
La Serra, Publico Ristorante, InterContinental Singapore Robertson Quay

Location:
1 Nanson Rd, Singapore 238909

By Invitation Only

Program Timeline [Day 1]

*Venue: **Main Conference Hall*** 27th June

Time	Program
09:00 ~ 10:00	Registration & Networking Coffee
Opening Session I **[Chair] Prof. Yong Sik Ok** President of IESGA & Program Director of APRU SWM, Republic of Korea	
10:00 ~ 10:05	**Opening Speech** **Prof. Yong Sik Ok** President of IESGA & Program Director of APRU SWM, Republic of Korea
10:05 ~ 10:15	**Congratulatory Remark** **Dr. Amy Khor** Senior Minister of State for Ministry of Sustainability and the Environment
10:15 ~ 10:30	**ESG Management: Opportunities and Challenges** **Prof. Jay Hyuk Rhee** President of IESGA & Director of ESG Research Institute, Korea University, Republic of Korea
10:30 ~ 10:45	**ESG Strategy: State of Practices in Asia Pacific** **Prof. Lawrence Loh** Director of Center for Governance and Sustainability, NUS Business School, Singapore
10:45 ~ 11:25	**Sustainable Investing in 2023 and Beyond** **Prof. Shawn Cole** Harvard Business School, US
11:25 ~ 11:40	***Networking Break***
11:40 ~ 12:20	**Research Partnerships to Advance a Sustainable Future** Prof. Shawn Cole, Prof. Jay Hyuk Rhee, Prof. Lawrence Loh, Prof. Yong Sik Ok, and Sumana Manohar
12:20 ~ 14:00	***Lunch & Interactive Session*** ("Ranking on the Biodiversity/Nature-Positive Commitment of the Top 200 Korean Firms" reported by IESGA)

Program Timeline [Day 1]

*Venue: **Main Conference Hall*** 27th June

Time	Program
	BlackRock Special Session **Circular Economy Practices by Industry** **[Chair] Prof. Jay Hyuk Rhee** President of IESGA & Director of ESG Research Institute, Korea University, Republic of Korea
14:00 ~ 14:05	**Speech by the Ellen MacArthur Foundation**
14:05 ~ 14:50	**Circular Economy Practices by Industry and Business Models** **Sumana Manohar** Head of Thematic Research for Fundamental Active Equities, BlackRock, UK
14:50 ~ 15:20	***Networking & Coffee Break***
	S&P Global Special Session **Global Business Lead, Climate Linked Credit & Risk Solutions** **[Chair] Prof. Yong Sik Ok** President of IESGA & Program Director of APRU SWM, Republic of Korea
15:20 ~ 15:50	**Geospatial Analysis of Nature-related Impacts and Dependencies, and Integration within the Taskforce on Nature-related Financial Disclosures (TNFD) Framework** **Olivier Trecco** Head of ESG Solutions of Asean/Japan/Pacific, S&P Global Sustainable 1, Singapore
15:50 ~ 16:20	**Scenario-based Analysis and Financial Impact Quantification of Key Transition and Physical Risks** **Prerna Divecha** Global Business Lead of Climate Linked Credit & Risk Solutions, S&P Global, Singapore
16:20 ~ 16:40	***Business Round Table*** Olivier Trecco and Prerna Divecha

Program Timeline [Day 1]

Venue: ***Main Conference Hall*** 27th June

Time	Program
	Opening Session II **[Chair] Prof. Jay Hyuk Rhee** President of IESGA & Director of ESG Research Institute, Korea University, Republic of Korea
16:40 ~ 16:50	**Ranking on the Biodiversity/Nature-Positive Commitment of the Top 200 Korean Firms** **Yoora Cho** Director of IESGA, Republic of Korea
16:50 ~ 17:10	**ESG in Smart Township Management** **Prof. Ho Pin Teo** Former Mayor of The North-West District of Singapore, Singapore
17:10 ~ 17:30	**Transforming State-Owned Enterprises (SOEs) in Korea: Performance Evaluation and K-ESG** **Prof. Hyunsun Choi** President of the Korean Association for Governance Studies, Republic of Korea
17:30 ~ 17:35	**Closing Remark** **Prof. Jay Hyuk Rhee** President of IESGA & Director of ESG Research Institute, Korea University, Republic of Korea

Program Timeline [Day 2]

*Venue: **Main Conference Hall*** 28th June

Time	Program
09:30 ~ 10:30	Registration & Networking Coffee
Battery Metals & Recycling **[Chair] Prof. Daniel S. Alessi** University of Alberta, Canada	
10:30 ~ 10:50	**Extraction of Lithium from Basinal Brines to Meet the Demand for Sustainable Energy Storage** **Prof. Daniel S. Alessi** University of Alberta, Canada
10:50 ~ 11:10	**Selective Extraction of Critical Metals from Retired Lithium-ion Batteries** **Prof. Daniel C.W. Tsang** Hong Kong Polytechnic University, China
11:10 ~ 11:30	**Lithium-ion Batteries: Research Activities Crossing the Frontiers and Supply Chains** **Dr. Xia Huang** University of Queensland, Australia
11:30 ~ 11:40	**Powering Sustainability: Trends and Innovations in the Battery Industry** **Sachini Senadheera** IESGA & Korea University, Republic of Korea
11:40 ~ 12:00	***Business Round Table*** Prof. Daniel S. Alessi, Prof. Daniel C.W. Tsang, Dr. Xia Huang, and Sachini Senadheera
12:00 ~ 14:00	***Lunch & Interactive Session*** ("Ranking on the Biodiversity/Nature-Positive Commitment of the Top 200 Korean Firms" reported by IESGA)

Program Timeline [Day 2]

Venue: ***Main Conference Hall*** 28th June

Time	Program
	Sustainable Plastic Management **[Chair] Prof. Injoo Chin** President of Korean Bioplastics Association, Republic of Korea
14:00 ~ 14:20	**Catalytic Upcycling of Plastic Waste** **Prof. Ning Yan** National University of Singapore, Singapore
14:20 ~ 14:40	**Valorization of PVC Waste into Aromatic Hydrocarbons Through VFD-Assisted Pyrolysis: A Sustainable Pathway Towards a High Value Circular Economy** **Dr. Elsa Antunes** James Cook University, Australia
14:40 ~ 15:00	**Digestion of Plastics Using In Vitro Human Gastrointestinal Tract and Their Potential to Absorb Emerging Organic Pollutants** **Prof. Patryk Oleszczuk** Maria Curie-Sklodowska University, Poland
15:00 ~ 15:10	***Business Round Table*** Prof. Ning Yan, Prof. Elsa Antunes, and Prof. Patryk Oleszczuk
15:10 ~ 15:40	***Networking & Coffee Break***
15:40 ~ 16:00	**Migration Behaviors and Environmental Risks of Phthalate Acid Esters and Microplastics From Agricultural Films** **Prof. Fang Wang** Chinese Academy of Sciences, China
16:00 ~ 16:20	**Polyvinyl Chloride Microplastics as a Co-contaminant with Silver Nanoparticles Can be Beneficial for Wastewater Treatment** **Prof. Eakalak Khan** University of Nevada, Las Vegas, US

Program Timeline [Day 2]

*Venue: **Main Conference Hall*** 28th June

Time	Program
16:20 ~ 16:40	**Potential Effects of Microplastics on Human Health** **Prof. Qianru Zhang** Chinese Academy of Agricultural Sciences, China
16:40 ~ 17:00	**Effects of Microplastics on Soil Microbial Communities and Greenhouse Gas Emissions** **Prof. Jingchun Tang** Nankai University, China
17:00 ~ 17:20	**Sustainable Polymers from Wood Derived Nanocellulose Sustainable Composites and Recyclable Elastomer Vitrimer Materials** **Dr. Jinlong Zhang** Arizona State University, US
17:20 ~ 17:40	***Business Round Table*** Prof. Fang Wang, Prof. Eakalak Khan, Prof. Qianru Zhang, Prof. Jingchun Tang, and Dr. Jinlong Zhang
17:40 ~ 17:45	**Closing Remark** **Prof. Sung Yeon Hwang** Director of IESGA & Kyung Hee University, Republic of Korea

Program Timeline [Day 2]

*Venue: **Medium Conference Hall*** 28th June

Time	Program
09:30 ~ 10:30	Registration & Networking Coffee
Net Zero & Renewable Energy **[Chair] Prof. Yong Sik Ok** President of IESGA & Program Director of APRU SWM, Republic of Korea	
10:30 ~ 10:50	**Energy Recovery for Sustainability and Environmental Well-Being** **Prof. Kian Jon Ernest Chua** National University of Singapore, Singapore
10:50 ~ 11:10	**Environmental Footprints of Bioenergy Production/Waste Management and Application of Machine Learning Methods** **Prof. Siming You** University of Glasgow, UK
11:10 ~ 11:30	**Human Health and Potential in a Warming World** **Prof. Jason Lee** National University of Singapore, Singapore
11:30 ~ 11:50	**Pursuing Sustainability through the Repurposing of Biology for Human and Planetary Health** **Prof. Wen Shan Yew** National University of Singapore, Singapore
11:50 ~ 12:00	***Business Round Table*** Prof. Kian Jon Ernest Chua, Prof. Siming You, Prof. Jason Lee, and Prof. Wen Shan Yew
12:00 ~ 14:00	***Lunch & Interactive Session*** (“Ranking on the Biodiversity/Nature-Positive Commitment of the Top 200 Korean Firms” reported by IESGA)
14:00 ~ 14:20	**What Carbon Neutrality and Net Zero Carbon Tells Us about the Required Innovation in Green Concrete: Vision and Challenges** **Prof. Harn Wei Kua** National University of Singapore, Singapore

Program Timeline [Day 2]

*Venue: **Medium Conference Hall*** 28th June

Time	Program
14:20 ~ 14:40	**NDCs in ASEAN Countries: Dreams or Reality? Case Studies: Indonesia and the Philippines** **Dr. Linda Yanti Sulistiawati** National University of Singapore, Singapore
14:40 ~ 15:00	**Conversion of Food Waste Derived Lipids to Bio-based Materials: Case of Polyurethane** **Prof. Sunita Varjani** City University of Hong Kong, China
15:00 ~ 15.10	***Business Round Table*** Prof. Harn Wei Kua, Dr. Linda Yanti Sulistiawati, and Prof. Sunita Varjani
15:10 ~ 15:40	***Networking & Coffee Break***
ESG Overview **[Chair] Prof. Jay Hyuk Rhee** President of IESGA & ESG Research Institute, Korea University, Republic of Korea	
15:40 ~ 16:00	**Capital Market Trends in Renewables/Energy Transition and What to Expect in 2024** **Jan Laubjerg** Global Head of Natural Resources, HSBC Bank Plc, UK
16:00 ~ 16:15	**Climate Complexities and Activism Rise – Issuer Risk Mitigation via Shareholder Engagement** **Julie Rhee** Senior Vice President of APAC Governance Advisory of Alliance Advisors LLC, US
16:15 ~ 16:30	**Need to further ESG Reporting toward Sustainable Development** **Prof. Shauhrat S. Chopra** City University of Hong Kong, China
16:30 ~ 16:45	**Korean Firm's Voluntary Disclosure of Climate Change Information and CEO's Educational Background** **Prof. Daehyun Cho** Korean Army Academy at Yeongcheon, Republic of Korea

Program Timeline [Day 2]

*Venue: **Medium Conference Hall*** 28th June

Time	Program
16:45 ~ 17:00	**ESG and Just Transition as New Challenges for Mining Companies: Case of Poland** **Prof. Joanna Kulczycka** Polish Academy of Sciences, Poland
17:00 ~ 17:15	**Reinventing the Family Business: Decarbonizing, ESG and Impact Investing** **Yuelin T. Yang** IMC Pan Asia Alliance Pte., Ltd., Singapore
17:15 ~ 17:30	**Illuminating Sustainability: The Role of LED, Connected Lighting and A-class Bulbs in Promoting Responsible Lighting Practices** **Vijay Venkatsubramanian** ASEAN Team Leader of Specification Sales, Signify, Singapore
17:30 ~ 17:50	***Business Round Table*** Jan Laubjerg, Julie Rhee, Prof. Shauhrat S. Chopra, Prof. Daehyun Cho, Prof. Joanna Kulczycka, Yuelin T. Yang, and Vijay Venkatsubramanian
17:50 ~ 17:55	**Closing Remark** **Prof. Jay Hyuk Rhee** President of IESGA & Director of ESG Research Institute, Korea University, Republic of Korea

Program Timeline [Day 3]

*Venue: **Main Conference Hall*** 29th June

Time	Program
09:30 ~ 10:30	Registration & Networking Coffee
Voluntary Carbon Market (VCM): Carbon Negative & Biochar **[Chair] Prof. Yong Sik Ok** President of IESGA & Program Director of APRU SWM, Republic of Korea	
10:30 ~ 10:45	**Negative Emissions Technologies: Engineered Carbon Removal Methods within Puro Standard** **Alvin Lee** Regional Head of Puro.earth APAC, Singapore
10:45 ~ 11:00	**The Power of Partnership – Forests for Global Net-Zero** **Hyungsoo Kim** Founder & CEO of TREE PLANET, Republic of Korea
11:00 ~ 11:15	**REDD+ and Voluntary Carbon Market: A Review of the Relationship and Potential Implications** **Prof. Yohan Lee** Seoul National University, Republic of Korea
11:15 ~ 11:30	**Biochar Research at CREATE E2S2** **Prof. Chi-Hwa Wang** National University of Singapore, Singapore
11:30 ~ 11:45	**Certified IBI & EBC Biochar Production in Singapore** **Dr. Tan Yong Tsong** Bluefield Renewable Energy Pte. Ltd., Singapore
11:45 ~ 12:00	**Microwave Processing: A Promising Technique for Transforming Bioresources into Value-added Biochar Products** **Prof. Su Shiung Lam** Universiti Malaysia Terengganu, Malaysia
12:00 ~ 12:15	**Towards Sustainable Agriculture: Biochar-Bacillus Consortium Reduces Fertilizers Dependency and Improves Oil Palm Seedlings Productivity** **Dr. Rosazlin Abdullah** Universiti Malaya, Malaysia

Program Timeline [Day 3]

*Venue: **Main Conference Hall***

29th June

Time	Program
12:15 ~ 12:35	***Business Round Table*** Alvin Lee, Hyungsoo Kim, Prof. Yohan Lee, Dr. Tan Yong Tsong, Prof. Su Shiung Lam, and Dr. Rosazlin Abdullah
12:35 ~ 14:00	***Lunch & Interactive Session*** ("Ranking on the Biodiversity/Nature-Positive Commitment of the Top 200 Korean Firms" reported by IESGA)
ESG from Consumers' Perspective (Korea Session) **[Chair] Prof. Yongjun Sung** President of Korea Society for Consumer and Advertising Psychology & Korea University, Republic of Korea	
14:00 ~ 14:20	**Attitudes Toward Climate Crisis: A Consumer Socialization Framework** **Youngju Jung** Korea Society for Consumer and Advertising Psychology & Korea University, Republic of Korea
14:20 ~ 14:40	**Sustainable Consumption: Reducing Food Waste in Restaurants** **Jungwon Kim** Korea Society for Consumer and Advertising Psychology & Korea University, Republic of Korea
14:40 ~ 15:00	**Sustainability in the Hospitality** **Soyeon Park** Korea Society for Consumer and Advertising Psychology & Korea University, Republic of Korea
15:00 ~ 15:10	***Business Round Table*** Youngju Jung, Jungwon Kim, and Soyeon Park
15:10 ~ 15:15	**Closing Remark** **Prof. Yong Sik Ok** President of IESGA & Program Director of APRU SWM, Republic of Korea

Program Timeline [Day 3]

Venue: ***Medium Conference Hall***

29th June

Time	Program
09:30 ~ 10:30	Registration & Networking Coffee
Innovations in Sustainable Environmental Practices **[Chair] Prof. Daniel S. Alessi** University of Alberta, Canada	
10:30 ~ 10:45	**Impact of Pharmaceuticals on Healthcare and Environmental Costs** **Prof. Sui Yung Chan** National University of Singapore, Singapore
10:45 ~ 11:00	**Lignin in Biochar Dissolved Organic Matter to Inhibit Microplastic Aging: Free Radical Mechanism and In Vivo-In Vitro Biotoxicity Analysis** **Prof. Honghong Lyu** Hebei University of Technology, China
11:00 ~ 11:15	**Effects of Key Properties of Rice Straw Biochar on Its Microbial Resistance Stability – Insight into Dissolved Organic Carbon, Pore Structure, and Persistent Free Radicals** **Prof. Yuxue Liu** Zhejiang Academy of Agricultural Sciences, China
11:15 ~ 11:30	**Beyond Carbon: The Critical Role of Dissolved Black Carbon in Biogeochemical Processes** **Prof. Fei Lian** Hebei University of Technology, China
11:30 ~ 11:45	**A Pilot Study of Arsenic Removal from Water by Biochar Electrodes** **Prof. Yinfeng Xia** Zhejiang University of Water Resources and Electric Power, China
11:45 ~ 11:55	**Effects of Phosphorus-modified Biochar on Soil Remediation and Plant Growth in Soil-Plant Interactive System** **Dr. Yuchen Wang** The Hong Kong University of Science and Technology, China

Program Timeline [Day 3]

Venue: ***Medium Conference Hall***

29th June

Time	Program
11:55 ~ 12:05	**Mitigation of Humic Acid Electron Competition Inhibition by Biochar During Anaerobic Digestion: Enhancing Syntrophic Acetate Oxidation with the Role of Electron Hopping Mediator** **Dr. Pengshuai Zhang** Shanghai Jiao Tong University, China
12:05 ~ 12:15	**Green Conversion of 5-hydroxymethylfurfural to 2, 5-furandicarboxylic Using Graphene Based Nitrogen-doped Carbon Catalyst** **Dr. Reeti Kumar** Hong Kong Baptist University, China
12:15 ~ 12:25	**The Role of Biochar in the Environment** **Chuanfang Fan** University of Chinese Academy of Sciences , China
12:25 ~ 12:35	**Understanding the Different Ageing Process on Colored and Non-Colored Polypropylene Microplastics** **Thaiyal Nayahi** Chulalongkorn University, Thailand
12:35 ~ 14:00	***Lunch & Interactive Session*** ("Ranking on the Biodiversity/Nature-Positive Commitment of the Top 200 Korean Firms" reported by IESGA)

Technical Tour

29th June

2023 Global ESG Forum in Singapore!
Exclusive Technical Tour

Embark on an exciting lab tour at E2S2 - CREATE in Singapore, discovering cutting-edge research and witnessing groundbreaking technologies that shape the future of innovation in Singapore's vibrant scientific community.

Time: 14:00 ~ 16:00

Venue: CREATE Tower Level 2

Poster Session

[Day 1~3]

No.	Title	Presenter	Affiliation
1	**Potential of Enhancing Carbon Neutrality Goals by Water Quality Prediction with Machine Learning: A Case Study of River Stream**	Ziyu Lin	Kyung Hee University, Republic of Korea
2	**A Study on Production of Turquoise Hydrogen According to Carbon Adsorption in Biochar**	Byeong Jun Jeon	Kookmin University, Republic of Korea
3	**Sustainable Removal of Hg and NO_X in Coal-Fired Powerplant**	Jung-Ho Park	Korea University Sejong Campus, Republic of Korea
4	**Study on Carbon Absorption and Hydrogen Production Characteristics Using Biochar Oven with Biomass**	Namkyun Oh	Kookmin University, Republic of Korea
5	**Remotely Operated Vehicle and Passive Sampling Techniques for the Sustainable Management of Contaminated Sediment**	Yongseok Hong	Korea University Sejong Campus, Republic of Korea
6	**An Integrative Review of ESG in Healthcare and Nursing**	BuKyung Park	Kyungpook National University, Republic of Korea
7	**Accelerating the Development of SMEs and Their Adaptation to Circular Economy Models and ESG Reporting: Spin Project in Poland**	Agnieszka Joanna Nowaczek	Polish Academy of Sciences, Poland

Poster Session

[Day 1~3]

No.	Title	Presenter	Affiliation
8	**Boosting Confidence in Biochar Product Value for Carbon Removal and Multiple Co-benefits: An Australian Perspective**	Sirjana Adhikari	Deakin University, Australia
9	**Sustainable Removal of Methane by Methane Oxidation Bacteria from Arctic Subsea-Floor Sediments Using a Sequencing Batch Bioreactor**	DongGyun Seo	Korea University Sejong Campus, Republic of Korea
10	**Development of Gold Amalgam Voltametric Microelectrode for the Quantification of Mn^{2+}**	HyunSoo Jo	Korea University Sejong Campus, Republic of Korea
11	**Life Cycle Assessment for Environmental Impact of Biochar Produced in Different Temperature**	Jiyeong Boo	Korea University, Republic of Korea
12	**Algae Cultivation for Feedstock of Bioplastics Production and Wastewater Bioremediation for Palm Oil Industry**	Cheah Wai Yan	Universiti Kebangsaan Malaysia, Malaysia
13	**Biodegradable Poly(butylene adipate-co-terephthalate) and Poly(lactic acid) Plastics: Degradation and Their Effects on Soil Properties**	Piumi Amasha Withana	Korea University, Republic of Korea

Poster Session

[Day 1~3]

No.	Title	Presenter	Affiliation
14	**NIR-Triggered High-Efficiency Self-Healable Protective Optical Coating for Vision Systems**	Ji Eun Jung	Korea Research Institute of Chemical Technology, Republic of Korea
15	**Design of Topology-Controlled Polyethers Toward Robust Cooperative Hydrogen Bonding**	Sang Ho Lee	Korea Research Institute of Chemical Technology, Republic of Korea
16	**Fast, Localized, and Low-Energy Consumption Self-Healing of Automotive Clearcoats Using a Photothermal Effect Triggered by NIR Radiation**	Jin Chul Kim	Korea Research Institute of Chemical Technology, Republic of Korea

Abstracts

I. Oral Session:

1. ESG Overview
2. Battery Metals & Recycling
3. Sustainable Plastic Management
4. Net Zero & Renewable Energy
5. Voluntary Carbon Market (VCM): Carbon Negative & Biochar
6. ESG from Consumer's Perspective
7. Innovations in Sustainable Environmental Practices

II. Poster Session

ESG Strategy: State of Practices in Asia Pacific

Lawrence Yeow Khoon Loh

National University of Singapore, Singapore

This session will highlight a most recent study of sustainability practices led by the speaker on leading companies across 13 Asia Pacific markets. Using a conceptual framework based on global sustainability standards and regional regulations, the session will uncover key findings in the universal principles of materiality and stakeholder engagement as well as in the specific environmental, social and governance (ESG) pillars. It will synthesize critical recommendations for the roles of business leaders and policymakers as well as educators and researchers.

ESG in Smart Township Management

Ho Pin Teo

National University of Singapore, Singapore

Climate change has pushed many countries and cities to adopt smart solutions to achieve sustainable development and management in the built environment. The experience of Covid-19 has further accelerated the adoption of digital technologies and robotics to improve business functions and work processes. In Singapore, over 80% of Singaporeans stay in public housing known as HDB flats. Over the last 60 years, the Housing and Development Board of Singapore has built over 1 million HDB flats. As a developer, HDB has implemented many innovative and sustainable initiatives to champion sustainability in our housing estates. To ensure that Singaporeans continue to enjoy a good quality environment, the government has formed town councils to manage, improve and upgrade the housing estates through various town improvement projects and estate upgrading programs. Over the last 30 years, the town councils has implemented various green projects and programs to build a clean and green living environment for their residents. Singapore is known as a "Garden City" and aspires to be a "City in the garden". The government has placed much emphasis to urge government agencies and private businesses to pursue Environmental, Social and Governance in their respective organisations. One aspect of ESG is the adoption of smart solutions for township management. These include the digitalization of facilities management processes, deployment of IOT sensors, dashboard management system for lift monitoring, and use of robots for maintenance works. This paper will share Singapore's experiences in adopting various smart township solutions in pursuit of ESG in the built environment.

Transforming State-Owned Enterprises (SOEs) in Korea: Performance Evaluation and K-ESG

Hyunsun Choi

The Korean Association for Governance Studies, Republic of Korea

Public instutions took a leading role for Korea's rapid economic development through building infrastructure, training human resources, and mobilizing resources at home and abroad. They provide essential public service such as electricity and water, and handle varisous tasks on behalf of the government. As of January 2020, there are 340 public institutions in Korea which are classified as public corporations, quasigovernmental institutions, or non-classified public institutions depending on their total number of employees, asset size, and the ratio of self-generating revenue to total amount of revenue. The total number of employees of all public institutions is about 411 thousand, and the ratio of their total budget to the nominal GDP is approximately 33.8 percent as of 2019.

Korea's performance evaluation system for public institutions has enhanced the performance, accountability, and transparency of these institutions. Since 2018, this management evaluation system has been modified with a focus on social value to strengthen the social responsibility. This is an important innovation for ESG model for public sector. In addition, Korea government announced K-ESG in 2021. Public institutions integrate K-ESG and social value for sustainability and governance.

Need to Further ESG Reporting Toward Sustainable Development

Shauhrat S. Chopra

City University of Hong Kong, China

Environmental, Social, and Governance (ESG) reporting has risen significantly and has become a new standard for markets worldwide. However, the quality of ESG reporting, and its "real" impact on sustainable development (SD) remains unclear and questionable. There is an urgently need for a ESG reporting transition towards a broader agenda of SD. The proposed transition will be discussed in the context of contemporary problems, challenges of ESG reporting, and the interdisciplinary approach required to develop solutions. A radical adjustment of traditional financial accounting systems to align with the future of ESG information disclosure systems is suggested. Although challenging, this evolution is possible through interdisciplinary research that synthesizes knowledge from ecology, engineering, and social sciences. The framework for innovating such interdisciplinary solutions can be based on Social and Environmental Accounting (SEA) scholarships. Moreover, future research themes will be presented that can contribute to the development of reporting and accounting systems for SD, which can help shape the future of sustainable finance

Korean Firm's Voluntary Disclosure of Climate Change Information and CEO's Educational Background

Daehyun Cho

Korea Army Academy at Yeongcheon, Republic of Korea

Climate Change is now recognized as the major risk factor worldwide, and the firms are facing some pressure from various stakeholders to disclose the climate change information. Most of the climate change information disclosure is now voluntarily done by the firms themselves, not mandated by the governmental regulations, thus the decision whether to voluntarily disclose this information or not differs from each firm. In this research, I hypothesized that the CEO's educational backgrounds are the one that can explain this differnece. Using Korean firm data, I tested the hypotheses by examining firms' responses to the Carbon Disclosure Project (CDP). The results show that Korean firms led by CEOs with higher level of education, degree from abroad, engineering major are more likely to participate in climate change disclosure than are other firms. This research contributes to the literature by extending the Korean literature on Corporate Environmental Responsibility (CER) and Environment, Social, and Governance (ESG). Also, this research suggests CEO's educational background as one of the explanatory variables for Korean firm's climate change related strategic decision.

ESG and Just Transition as New Challenges for Mining Companies: Case of Poland

Joanna Kulczycka* , Ewa Zofia Dziobek, Agnieszka Joanna Nowaczek*

Polish Academy of Sciences, Poland

One of the key long-term goals of the United Nations and the European Union (EU) is to reduce global carbon dioxide (CO2) emissions to net zero by 2050. To ensure that the transition to a climate-neutral economy takes place in a fair manner, leaving no one behind, and to support the development and implementation of national just transition plans, the EU Just Transition Mechanism (JTM) has been set up to provide EU Member States with dedicated financial resources and technical assistance. The main challenges facing JTM relate to overcoming the focus on national allocations, not being limited to the energy sector, and working with the private sector and stakeholders. A just transition is driven both by environmental considerations and by structural changes affecting labor markets. Many transformation plans have already been created for coal regions in Europe, and new projects for supporting its realization and developing new value-added connected with decarbonizations, i.e., SITRANS Life project, have been started. Accelerating the transformation process and achieving a balance between the economy, environment, and society is essential for the raw materials sector. Environmental and social issues are crucial for the sustainable extraction of mineral resources.

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ESG and Just Transition as New Challenges for Mining Companies: Case of Poland

Joanna Kulczycka* , Ewa Zofia Dziobek, Agnieszka Joanna Nowaczek*

Polish Academy of Sciences, Poland

To mitigate risk, companies must adhere to the highest environmental standards, be transparent, and fully respect local communities. There is an increasing number of activities in these areas. In recent years, the more general term CSR (Corporate Social Responsibility) has been replaced by the more precise term ESG (Environmental, Social and Governance). However, this does not change the goal that companies should take into account at the stage of building business strategies: social interests, environmental protection, as well as relations with various groups of stakeholders. This is due to the growing requirements in supply chains and greater awareness of the importance of non-financial reporting defined by ESG reporting requirements that help measure and quantify these types of activities, part of which is the EU Taxonomy, a system of uniform classification of activities for sustainable development. Even though mining plays a key role in low-carbon and energy technologies, there are more and more mining guidelines are being introduced, including critical raw materials, waste management, risk, social license to operate (SLO), partnerships and platforms are being created (EIT KIC RM, Raw Materials Information Systems, etc.) providing analysis and expertise, the EU continues to work on how to assess sustainable mining activities and what criteria should be applied. Even if the executive acts are not yet known, ESG strategies in mining companies and non-financial reporting have already started. A more detailed description of the new challenges related to the Polish mining industry will be presented.

Reinventing the Family Business: Decarbonizing, ESG and Impact Investing

Yuelin T. Yang

IMC Pan Asia Alliance Pte., Ltd., Singapore

Many family businesses in Asia were founded post-World War 2. They are going through generational transition including wealth transfers leading to the rise of family offices in Asia. Similar to the family business, family offices often have a long-term orientation and focus on values given the family name is on the door. At the same time, many Asian families retain the original core business. The next generation of family leaders face the challenge of decarbonizing these existing businesses. At the same time and in parallel, many of the next gen are interested in ESG and impact investing. By the late 2010s, ESG emerged and became mainstream because of its importance as a framework for the investment community to assess how exposed a company is to non-financial risks. ESG ratings agencies and reporting frameworks proliferated. Climate change has increased public awareness of the impact of private commercial activities over exploiting the environment (air, water, biodiversity etc) at high social cost.

In parallel, for corporates, stakeholder capitalism and sustainability became part of the lexicon. Corporate sustainability is an umbrella term for doing good (eg, ethical and responsible business practices) encompassing all of a company's efforts to reduce its impact on the world. There are several important differences: (1) ESG is specific (data driven) and measureable while sustainability is vague, (2) ESG is investor focused with financially connected metrics which are subset of sustainability metrics, (3) business sustainability is not standardized itself as it means different things to different companies, and (4) ESG focuses on the financial impact of the world on the company while sustainability is concerned with the impact of the company on the environment.

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Reinventing the Family Business: Decarbonizing, ESG and Impact Investing

Yuelin T. Yang

IMC Pan Asia Alliance Pte., Ltd., Singapore

For corporates, ESG requires a sustainability strategy and plans that are key to address the 5 C's: (1) climate change which may disrupt business models and create new opportunities, (2) cost of capital, (3) customers and consumers who are increasingly focused on sustainability, (4) compliance with more regulations including for climate change and (5) corporate values to attract more sustainability conscious younger workers.

Yuelin will share the ongoing transformation at IMCPAA, which is a 4th generation family business originating in Shanghai and now headquartered in Singapore, for decarbonizing and impact investing. IMC has been providing solutions to serve the industrialization of Asia by owning and operating assets in the shipping and related industry, including shipyards, ports, container terminals, etc. The holding company, IMCPAA, has evolved with Asia's progress from industrialization to consumerism and services by being an active venture investor in the food, healthcare and education areas in Southeast Asia.

Illuminating Sustainability: The Role of LED, Connected Lighting and A-class Bulbs in Promoting Responsible Lighting Practices

Vijay Venkatsubramanian

ASEAN Leader Specification Sales, Signify, Singapore

Sustainability has become a buzzword in many industries, and the lighting industry is no exception. With the growing concern about energy consumption and its impact on the environment, responsible lighting practices have become increasingly important. Ultra efficient LED, connected lighting, human centric circadian lighting, circularity, renewable energy light sources are responsible lighting practices and contribute to sustainable development. Ultra efficient LED is the most energy-efficient lighting technology. They use less energy than traditional light sources and have a longer lifespan. It is a popular choice for end users, sustainability and electrical consultants, designers and architects who want to reduce energy consumption and carbon emissions. Ultra efficient A-class LED light sources are also highly versatile and can be used in a variety of lighting applications. Connected lighting is another innovative technology that is gaining popularity. It allows lighting fixtures to communicate with each other and with other devices, such as sensors and smartphones. This creates a network of smart lighting that can be controlled and monitored remotely. Connected lighting can help to reduce energy consumption by automatically adjusting the lighting intensity based on the demand and presence of people and natural day light. Human centric circadian lighting is another important tool that helps in promoting human health and wellbeing in indoor spaces were daylight is not available. Circularity is a key trend that emphasis on recyclability of light fixtures. Renewable energy light sources like solar streetlights consume zero energy from the grid.

Extraction of Lithium from Basinal Brines to Meet the Demand for Sustainable Energy Storage

Daniel S. Alessi

University of Alberta, Canada

The demand for critical metals used in lithium-ion batteries is projected to outstrip supply by the end of this decade. Conventional lithium sources, including salars and hard rock mines, will continue to provide a substantial fraction of that demand, but lithium production from unconventional sources is projected to be necessary to address the emerging supply gap. Among the most promising of these unconventional lithium sources is brines located in deep sedimentary basins around the world. While these brines contain far lower concentrations of lithium than conventional sources – normally tens to hundreds of parts-per-million – oil and gas operations along with geothermal power plants often have infrastructure in place that bring lithium-bearing brines to the surface and could be leveraged in a commercial plant to extract and produce lithium salts. However, because of the relatively low concentrations of lithium and a requirement to process large volumes of brine, materials that are highly selective for lithium must be developed in order for the process to become economic. Among the most promising direct lithium extraction (DLE) materials are synthetic spinel lithium manganese oxides (LMOs). LMOs are produced from easy-to-source and green reagents, are highly selective towards lithium while excluding other ions in brines, and have already been commercialized for lithium battery applications. Commercialization of LMOs as a DLE technology is limited by several current research challenges. Among the most important is sorbent degradation due to the reduction of structural Mn(IV) to more soluble Mn(III) and Mn(II) caused by the presence of organic compounds and sulphide in the target brines. This talk will introduce these barriers to commercialization and demonstrate that coating and doping of LMO nanoparticles is a promising method to inhibit the reductive dissolution of the sorbents, extending their lifetime. Finally, a case will be made for lithium extraction from sedimentary brines from both economic and carbon offset perspectives.

Biochar for Stabilization/Solidification of Waste Incineration Fly Ash

Daniel C.W. Tsang

Hong Kong Polytechnic University, China

Low-carbon stabilization/solidification (S/S) is increasingly important for the sustainable treatment of hazardous wastes. In this study, we integrated carbon-negative rice husk biochar (RBC) and yard waste biochar (YBC) as green additives into the binder for S/S of municipal solid waste incineration (MSWI) fly ash. Experimental results illustrated that adding both biochars promoted cement hydration reaction via pozzolanic reaction and internal curing. In particular, the incorporation of 10 wt.% RBC (rich in activated Si) significantly increased the content of C-S-H gel from 41.6 wt.% (control sample) to 52.0 wt.% and increased the average degree of connectivity of C-S-H gel from 1.43 to 1.52 as indicated by quantitative X-ray diffraction and 29Si nuclear magnetic resonance analysis. Incorporating RBC and YBC (20 or 30 wt.%) enhanced the immobilization efficiency of potentially toxic elements in MSWI fly ash due to the additional hydration products and high adsorption ability of biochar. For instance, in R-80FA and Y-80FA samples (namely, 20 wt.% binder dosage, of which RBC or YBC accounted for 10 wt.% of binder), the immobilization efficiency for Pb could reach 96.2% and comply with the leachability limit. The biochar-modified S/S specimen achieved comparable strength to the cement-based S/S blocks, exhibiting a mechanically stable solidified matrix for engineering application. Therefore, this study expands the emerging application of biochar and demonstrates that biochar-augmented binder can ensure low-carbon and high-performance S/S of hazardous waste incineration fly ash.

Lithium-ion Batteries: Research Activities Crossing the Fronters and Supply Chains

Xia Huang, Lianzhou Wang*

The University of Queensland, Australia

Lithium-ion batteries (LIBs) have powered the evolution of portable devices in the past 40 years, and they are electrifying our cars to help eliminate air pollution/carbon emissions and reduce petroleum reliance. One the one hand, LIBs that have higher energy density, lower cost and higher reliability than the state-of-the-art technology are still eagerly demanded to enable longer driving range, more affordable and safer electric vehicles (EVs). Huge and ongoing research and development efforts are pushing the boundaries of LIB technology by innovating in the electrode and electrolyte material aspects. On the other hand, along with the bourgeoning LIB markets and implementation of LIBs as national strategies, the supply chains of LIBs thrive, such as raw materials extraction, processing and battery components manufacturing. Our research activities focus on LIBs, from developing robust cathode materials, such as the design of epitaxial growth process for atomic-thin coating to enable superior cycling life of high-voltage spinel cathodes, and the development of cutting-edge lithium, manganese rich cathode materials, to collaborating with a wide range of international and local companies towards making the low profit mining raw materials to high value-added materials for LIBs.

Powering Sustainability: Trends and Innovations in the Battery Industry

Sachini Senadheera, Yong Sik Ok*

Korea University, Republic of Korea

The battery industry is experiencing a significant transformation driven by the increasing demand for clean energy solutions and the urgent need to address climate change. Within this context, battery reuse and recycling have emerged as crucial factors, presenting both challenges and opportunities. Significant advancements in battery technology, particularly in the realm of lithium-ion batteries, have resulted in notable enhancements in energy density, charging speed, and overall lifespan. These improvements have played a vital role in expanding the capabilities and applications of batteries across various industries. Moreover, alternative battery technologies like solid-state and lithium-sulfur batteries hold great potential for achieving even higher energy density, faster charging capabilities, and enhanced safety. These alternative technologies are being actively explored and developed to address the limitations of lithium-ion batteries and further propel the evolution of battery technology. However, it is crucial to address challenges associated with the complex electrochemical processes of lithium-ion batteries, potential safety concerns, and their limited durability. Korea has set clear targets to achieve net-zero economies by 2050 and recognizes the significance of battery metals and the need for efficient recycling practices. The country is proactively tackling these challenges by establishing recycling facilities, investing in advanced recycling technologies, and implementing government initiatives such as extended producer responsibility (EPR) programs. By embracing a circular economy for battery materials, Korea aims to reduce the environmental impact, conserve valuable resources, and strengthen the resilience of the battery industry's supply chain. These efforts position Korea as a leader in sustainable sourcing and recycling of battery metals, driving the growth of a thriving and environmentally conscious battery industry that contributes to a greener and more sustainable future.

Low Carbon Fuels and Chemicals

Ning Yan

National University of Singapore, Singapore

Low carbon chemical synthesis and fuel production are critical to achieving sustainable and environmentally-friendly energy systems. Ammonia has the potential to be an important fuel for hydrogen production, while CO_2 conversion offers carbon based renewable fuels and nutrients. Furthermore, plastic upcycling is crucial for polymer synthesis that can close the loop and reduce plastic waste. This presentation will cover recent advancements in these areas, including innovative approaches for ammonia cracking for H_2 generation, CO_2 capture and reduction to methanol, formic acid, and nutrients and plastic recycling for low carbon fuels and chemicals. The potential for these technologies to drive a sustainable and resilient energy future will also be discussed.

Valorization of PVC Waste into Aromatic Hydrocarbons through VFD-Assisted Pyrolysis: A Sustainable Pathway Towards a High Value Circular Economy

Elsa Antunes[1*], Tewodros Dada[1], Colin Raston[2]

[1]*James Cook University, Australia*
[2]*Flinders University, Australia*

Polyvinyl chloride (PVC) is among the most prevalent plastics globally, leading to substantial waste and associated environmental concerns. Conventional waste management strategies fall short in addressing the increasing demand for sustainable disposal methods. This study introduces an innovative and sustainable technique to produce aromatic hydrocarbons (AHs) from PVC waste using vortex fluidic device (VFD)-assisted pyrolysis. The VFD's unique capacity to enable rapid, high-intensity chemical reactions and selective bond cleavage promotes efficient PVC dechlorination, while the subsequent pyrolysis stage facilitates controlled thermal decomposition into AHs. The first step, VFD-assisted dechlorination, rapidly and selectively removes chlorine atoms from the PVC backbone. The VFD experiments were conducted at varying shear rates of 3500, 4500, 5500, and 6500 rpm. The dechlorinated PVC was then subjected to pyrolysis at different temperatures (450, 550, and 650˚C) to produce a diverse array of AHs. Py/GC-MS results revealed that increasing the rpm led to higher yields and selectivity of AHs, with benzene as the predominant compound. The maximum benzene yield (78.34%) was obtained at a pyrolysis temperature of 650˚C and a shear rate of 6500 rpm, exhibiting no detectable HCl. This study underscores the potential of VFD-assisted pyrolysis as a sustainable and effective strategy for PVC waste valorization, mitigating its environmental impact while generating valuable resources for the chemical industry.

Digestion Of Plastics Using in Vitro Human Gastrointestinal Tract and Their Potential to Adsorb Emerging Organic Pollutants

Aleksandra Bogusz[1], Ewa Baranowska-Wójcik[2], Yong Sik Ok[3], Patryk Oleszczuk[4*]

[1]National Research Institute, Poland
[2]University of Life Sciences in Lublin, Poland
[3]Korea University, Republic of Korea
[4]Maria Curie-Sklodowska University, Poland

Excessive plastic use has inevitably led to its consumption by organisms, including humans. It is estimated that humans consume 20 kg of plastic during their lifetime. The presence of microplastics in the human body can carry serious health risks, such as biological reactions e.g. inflammation, genotoxicity, oxidative stress, apoptosis, as well toxic compounds leaching of unbound chemicals/monomers, free radicals or adsorbed organic pollutants, which mainly depend on the properties of the ingested plastic. Plastics are exposed to different substances (e.g., enzymes and acids) in the digestive system, which potentially affects their properties and structure. By stimulating the human digestive system and applying a set of advanced analytical tools, we showed that the surface of polystyrene and high-density polyethylene plastics frequently in contact with food undergoes fundamental changes during digestion. This results in the appearance of additional functional groups, and consequent increase in the plastic adsorption capacity for hydrophobic ionic compounds (such as triclosan and diclofenac) while reducing its adsorption capacity for hydrophobic non-ionic compounds (such as phenanthrene). Micro- and nanostructures that formed on the flat surface of the plastics after digestion were identified using scanning electron microscopy. These structures became defragmented and detached due to mechanical action, increasing micro- and nanoplastics in the environment. Due to their size, the release of plastic nanostructures after digestion can become an “accidental food source” for a wider group of aquatic organisms and ultimately for humans as the last link in the food chain. This, combined with improved adsorption capacity of digested plastics to hydrophobic ionic pollutants, can pose a serious threat to the environment including human health and safety.

Migration Behaviors and Environmental Risks of Phthalate Acid Esters and Microplastics from Agricultural Films

Fang Wang*, Yu Wang

Chinese Academy of Sciences, China

Plastic films have become an integral part of fruit and vegetable production systems, but they are a source of phthalic acid esters (PAE) and microplastics that pose health risks to humans and other living organisms. Despite recent efforts, the issue of the migration and environmental fate of phthalic acid esters and microplastics derived from agricultural films remains unresolved and therefore still open for investigation. Here, we analyzed 50 agricultural films and found that their PAE concentrations varied widely from 2.59 to 282,000 mg/kg. Bis(2-ethylhexyl) phthalate (DEHP) was found in most agricultural plastic films analyzed, especially those made of polyvinyl chloride and metallocene polyethylene. Under the influence of sunlight and other environmental factors, agricultural plastic films age and deteriorate, releasing PAEs and turning into microplastics. Even biodegradable plastic films may not fully degrade depending on environmental conditions, and micro- and nano-plastics derived from them may persist in the environment. These microplastics often have their surfaces charged by weathering, mechanical crushing, and other environmental processes. In this regard, we quantified the fluorescence intensity of positively and negatively charged microplastics on nine different soil types to investigate the mechanism of interaction between microplastics and soil.

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Migration Behaviors and Environmental Risks of Phthalate Acid Esters and Microplastics from Agricultural Films

Fang Wang*, Yu Wang

Chinese Academy of Sciences, China

The results showed a strong affinity for microplastic attachment to the soil, and electrostatic interactions and physical entrapment were the dominant mechanisms for microplastic attachment to the soil. In another study, we found that plants could take in microplastics through their roots and then move them to their above-ground parts. Microplastics could also get into plant leaves through stomata and cuticles. In light of these findings, we propose: (1) either rethinking the manufacturing process to reduce the concentration of PAE in agricultural plastic films or warning buyers and producers about potential risks, (2) strengthening the recycling and reuse of agricultural film waste to reduce environmental plastic pollution, and (3) finding ways to increase the rate of degradation of degradable agricultural films so that complete degradation can be achieved and microplastic pollution can be avoided.

Polyvinyl Chloride Microplastics as a Co-contaminant with Silver Nanoparticles Can Be Beneficial for Wastewater Treatment

Nampetch Charanaipayuk[1], Tawan Limpiyakorn[1], Eakalak Khan[2*]

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Silver nanoparticles (AgNPs) and microplastics are emerging water contaminants of the decade. They share similar fate and transport in wastewater treatment plants (WWTP) as they tend to accumulate in biosolids. Since both contaminants have negative effects on microbial growth, ammonia-oxidizing microorganisms in the aeration tanks of WWTP are at risk for inhibition and consequently nitrification process fails. This study investigated the effects of AgNPs and microplastics, specifically polyvinyl chloride (PVC), on ammonia-oxidizing activity and community. No inhibition of ammonia oxidation rate was observed at 0.1 mg/L AgNPs. Partial inhibition was found at 0.5 and 1 mg/L AgNPs, while complete inhibition occurred at higher concentrations of 2.5, 5, and 10 mg/L AgNPs. qPCR targeting ammonia-oxidizing archaea (AOA), ammonia-oxidizing bacteria (AOB), and comammox amoA genes indicated that the numbers of the AOB amoA genes decreased when AgNPs were ≥ 2.5 mg/L while the comammox amoA genes dropped at ≥ 0.5 mg/L of AgNPs. Inhibition of AOA was found at AgNP concentrations above 0.5 mg/L but is substantially less compared to AOB and comammox. This study suggests that the three ammonia-oxidizing microorganisms have different responses to AgNP. The co-effect of AgNPs and PVC was studied in microcosms at concentrations of 0.5 mg/L and 500 mg/L, respectively.

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Polyvinyl Chloride Microplastics as a Co-contaminant with Silver Nanoparticles Can Be Beneficial for Wastewater Treatment

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The results showed that the PVC microplastics had no inhibitory effects on the ammonia oxidation rate. Interestingly, the microcosms, in which the PVC was pre-shaken for 7 days before adding the nitrifying sludge and AgNPs showed a faster ammonia oxidation rate than the microcosms containing the nitrifying sludge and AgNPs with and without fresh (not shaken) PVC. This suggests that the pre-shaken PVC microplastics may reduce the toxicity of AgNPs. qPCR results indicated that the PVC microplastics did not suppress AOA, AOB, and comammox. This study demonstrates that the presence of PVC microplastics in wastewater can be beneficial to nitrification process by potentially quenching the inhibitory effect of AgNPs on ammonia oxidizing microorganisms.

Effects of Microplastics on Human Health：Case of Human Lung Cells

Qianru Zhang*

Chinese Academy of Agricultural Sciences, China

Global plastic annual production has increased to over 300 million tons. In the natural environment, bulk plastics are prone to photodegradation, physical abrasion, hydrolysis and biodegradation, which lead to the generation of microplastics (< 5 mm) and nanoplastics (< 100 nm) in large quantities. As a result of plastic particles massively accumulating in the environment, scientists have focused on the production of biodegradable plastics and deposition of plastic particles using biochars and biofilms in terrestrial ecosystems. However, airborne particles are difficult to control because they can be transported by wind and thus are dispersed in the atmosphere. In recent years, microplastics have been widely detected in the atmosphere all over the world, and polystyrene particles have been proven to be one of the main components of atmospheric microplastic pollution. These airborne microplastics are thought to be further degraded into smaller nanometer-sized particles. Given that nanoplastics can be transported over longer distances than microplastics, they may be potentially more widespread and concentrated in the environment than microplastics. Furthermore, the characteristics of nanoplastics such as their extremely small diameter, high tissue affinity and high adsorption capacity make them easier to be internalized and accumulated by cells than microplastics.

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Effects of Microplastics on Human Health：Case of Human Lung Cells

Qianru Zhang*

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Nanoplastics are easily inhaled by humans after which they travel to the bronchi and deposit in the alveoli. Our study provided evidence that as a novel hazardous material, nanoplastics could easily enter the cytoplasm and even the nucleus of human alveolar epithelial cells, which resulted in inflammation, apoptosis, genotoxicity and death; induce epithelial-to-mesenchymal transition (EMT) in human alveolar epithelial cells with the activation of NADPH oxidase 4 (NOX4). And through a dynamic network; and activate NOX4 potentially leads to a feedback loop with persistent mitochondria dysfunction and ER stress. The toxic effects and related mechanisms of nanoplastics are closely related to their concentration, particle size and surface charge. This study offers insights into the toxicological mechanisms of nanoplastics on the respiratory epithelium system of humans.

Effects of Microplastics on Soil Microbial Communities and Greenhouse Gas Emissions

Jingchun Tang

Nankai University, China

In recent years, microplastics in soil have gradually entered the vision of researchers, and microplastics entering the soil environment will undergo migration and transformation through many ways, such as aging and adsorption of other pollutants in the soil, which have an impact on soil microbial communities and greenhouse gas emissions. The impact of soil microplastics on microbial communities is mainly through two ways: changing microbial diversity and community composition, and affecting microbial metabolic activity. The impact of soil microplastics on microbial diversity and community composition is mainly through changing soil pH, changing soil bulk density, biased selection of microorganisms that can degrade microplastics, and the adsorption of pollutants and desorption of additives by microplastics themselves. At the same time, microplastics can affect microbial communities to varying degrees by influencing soil aggregation performance, changing soil carbon input and nitrogen and phosphorus content, stimulating enzyme activity, and gene expression. The impact of microplastics on soil is not only reflected in microbial communities, but also in greenhouse gas emissions.

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Effects of Microplastics on Soil Microbial Communities and Greenhouse Gas Emissions

Jingchun Tang

Nankai University, China

This indicates that the microplastics in fertilized soil promote the release of CO_2, and this is also affected by the particle size of the microplastics. For N_2O emissions, microplastic particles increase soil porosity and improve air flow in the soil. The increase in oxygen content in soil pores will have a certain inhibitory effect on denitrification bacteria. Microplastics can stimulate enzyme activity and gene expression. Microplastics significantly increase the copy number of nap and nas genes in the process of NO_3^- to NO_2^- reduction, while increasing the copy number of nir and nos genes in the process of NO_2^- to N_2O reduction, promoting the production of N_2O. In dry field soil, microplastics all decreased the absorption of CH_4 in soil, and the impact of large size microplastics was more significant. Based on the previous explanation, future research directions were proposed.

Sustainable Polymers from Wood Derived Nanocellulose Sustainable Composites and Recyclable Elastomer Vitrimer Materials

Jinlong Zhang

Arizona State University, US

The development of sustainable polymers from renewable resource derived nanocellulose and recyclable elastomer vitrimer materials is of importance to address the environmental pollution issues. Especially, the reused and recycled waste polymer materials are also potential to reduce the carbon dioxide release and contribute for the carbon neutrality. To address the issue above, I have designed a new type of polyurethane-urea elastomer vitrimer material, which could be repeatedly compounded up to four times. This elastomer vitrimer materials still maintained excellent mechanical performance after recycling cycles for several times. In addition, cellulose nanocrystals (CNCs), as an inexpensive, renewable, and biodegradable nanomaterials, have received an increasing attention in recent years. CNCs possess many attractive properties, which makes them useful in CNCs reinforced nanocomposites. However, the acrylic thermoplastic elastomeric matrix and CNCs were incompatible, and the molecular scale interactions between them were not sufficient to produce a satisfactory enhancement in properties.

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Sustainable Polymers from Wood Derived Nanocellulose Sustainable Composites and Recyclable Elastomer Vitrimer Materials

Jinlong Zhang

Arizona State University, US

To address this issue, the rigid rod-type CNCs were chemically decorated with hydrophobic polymers, and such surface tailored CNCs contributed to improved interfacial miscibility and enhanced mechanical performance of nanocomposites. Besides, the surface functionalized CNCs with responsive polymers, which respond to external stimuli, has been of significant interest. A novel temperature responsive poly (N- vinylcaprolactam) functionized CNC smart materials were synthesized via a controlled radical polymerization method and the resulted CNC functional materials showed temperature responsive property. Finally, the high performance nanocellulose composites with physically cross-linked treatment was also reported. All of these research work will be present during the 2023 Global ESG Forum in Singapore. Finally, the high performance nanocellulose composites with physically cross-linked treatment was also reported. All of these research work will be present during the 2023 Global ESG Forum in Singapore.

Harvesting Hot and Cold Waste Energy for Continuous Sustainability

Kian Jon Ernest Chua

National University of Singapore, Singapore

Due to existing issues related to global energy security and ecological environment degradation, waste thermal energy recovery R&D has gain traction over the last twenty years. Waste thermal energy sources manifest in different forms and types (solid, liquid, gas) spanning different temperature ranges (-160 to 900 ˚C). In addition, useful utilities, namely, electricity, cooling, heating, potable water, and dry and cool air, can be produced from a judiciously integrated thermal energy system that is fed from the harvested waste thermal heat. In this presentation, we present two thermal plants for energy recovery – one hot and the other cold. Specifically tailored for the tropics, the two thermal plants can contribute to renewable energy applications, cost savings, and space-efficiency. More importantly, they can significantly reduce energy consumption and trim the amount of carbon dioxide emitted to the environment while meeting varying needs of electricity, potable water, cooling, and heating. The first plant comprises a thermally integrated smart plant that uses natural gas as the energy source to power micro turbines to produce electricity. Waste heat from the exhaust gas generated is recovered and channeled back to drive heat-driven chillers to produce chilled water for the purpose air-conditioning. Further, this plant can desalinate any wastewater feeds to produce portable water. The second plant involves the harvesting of cold energy during LNG to CNG conversion to deliver useful utilities, primarily, chilled water, electricity, cooled dry air, and potable drinking water. Key operational data have highlighted that up to 80% of the cold energy can be harvested which would otherwise be released to the environment. The key innovation to the two presented thermal plants encompasses the novel cascading hierarchy of hot and cold energy recovery processes to produce invaluable utilities in the smartest manner in order to strengthen the energy-water-environmental nexus.

Environmental Footprints of Bioenergy Production/Waste Management and Application of Machine Learning Methods

Siming You

University Glasgow, UK

Sustainable bioenergy production and waste management play important roles in achieving Climate Action and Sustainable Cities and Communities as part of the United Nations Sustainable Development Goals. Environmental footprints of associated energy and environmental systems and developments are one of the key criteria that have been commonly incorporated for their optimal design. This talk will cover some of our recent environmental impact assessment studies on bioenergy production and waste management in the UK. Some of considered technologies include gasification, anaerobic digestion (or co-digestion), and transesterification, and related feedstocks include municipal solid waste, food waste, cow slurry, and rapeseed oil. The aim of the research is to initiate mapping the range of possibilities of bioenergy production/waste management in facilitating UK's action in achieving clean and low-carbon production. Environmental footprint assessment is often plagued by lack of reliable data input. Machine learning methods can be used to mitigate the issue/challenge e.g., by supplying reliable process production prediction. This talk will also cover some of our recent effort of developing machine learning-based models for more accurate, flexible environmental impact assessment. Our models for predicting gasification, pyrolysis and anaerobic digestion production will be introduced. The application of machine learning modelling for the life cycle assessment of an integrated anaerobic digestion-heat pump development will be presented.

Human Health and Potential in a Warming World

Jason Lee

National University of Singapore, Singapore

Feeling hot especially in the tropics is often perceived as normal, but most are unaware of how heat can be detrimental to our overall health, well-being and performance. While heat stress is the effect of the environment on the individual, heat strain is the resultant thermal load the body experiences predominantly from the weather, workload and clothing. The three pillars of human health and performance are diet, exercise and sleep, and each of these can be hindered by heat stress. Although heat stress is typically associated with outdoor work, it is also present in indoor workplace environments involving processes that emit radiant heat with inadequate ventilation. Workers, including military personnel, firefighters, law enforcers, construction workers, healthcare workers, gig workers and food stall hawkers are particularly affected by the heat. Heat stress not only increases the risk of heat injury but can also interfere with work productivity. In addition, heat stress can compromise decision making, thereby increasing the risk of accidents. Long-term exposure to heat stress can also induce diseases such as chronic kidney disease of non-traditional causes even in healthy working adults. The downstream heat-related incidents are often due to a poor start state and therefore so special attention must be given to individuals who are unwell, under-recovered or on medication, as these risk factors would increase one's susceptibility to heat injury.

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Human Health and Potential in a Warming World

Jason Lee

National University of Singapore, Singapore

Beyond the workplace, heat stress can also affect our way of life. For example, the public is encouraged to adopt an active lifestyle through exercise. However, high local temperatures do not favour outdoor activities. Many would therefore choose to exercise only during the cooler periods, hence limiting our opportunities to exercise outdoors. If we do not act to reduce heat stress, it is expected that as temperatures continue to rise prospectively, the avoidance of outdoor exercise due to thermal discomfort would ensue. Chronically, this implies that both our physical and mental health would be compromised. The ageing population, which includes those suffering from chronic diseases, is also affected by heat stress. A multidisciplinary approach is therefore required to tackle this multifaceted whole of society public health problem.

Repurposing Biology Through Synthetic Enzymology: For Human and Planetary Health

Wen Shan Yew

National University of Singapore, Singapore

Synthetic Enzymology has been increasingly used to engineer enzymes within biological systems for the repurposing of biology for purposeful function. On that note, the talk will touch on the use of Synthetic Enzymology in the sustainable production of therapeutics such as cannabinoids and ergot alkaloids. Traditional production involves crop cultivation that could otherwise be used for food production; in addition, industrial agriculture is one of the largest contributors to carbon emissions worldwide and is unsustainable. Through a process known as fermentation, modified yeast can be grown using sugar to produce therapeutics and active pharmaceutical ingredients. Natural fermentation has been used throughout human history for food production, most notably in the production of bread and beer. Just like how baker's yeast has been used to produce the alcohol and flavours in beer, fermentation using modified yeast can now produce sustainable therapeutics. In essence, we are harnessing fungal cells to act as miniature factories to produce raw compounds for medicines. Production using this method, instead of using arable land for traditional crop cultivation, is a step closer to sustainability and planetary health, as it shifts the reliance away from traditional industrial agriculture that has a large carbon footprint and is vulnerable to climate change.

What Carbon Neutrality and Net Zero Carbon Tells Us About the Required Innovation in Green Concrete: Vision and Challenges

Harn Wei Kua*, Alvin Ee

National University of Singapore, Singapore

In the past one and a half decade, encouraging progress has been made in understanding the life cycle environmental impacts of biochar, and the potential of using biochar as a partial cement in concrete as a mean of reducing the net carbon emission of concrete. For example, it was found that recycling stover waste as feedstock for producing biochar from pyrolysis can yield a net negative (-846 $kgCO_2$-e per kg of feedstock) carbon emission.

For the past 10 years, applying biochar in concrete has developed into a sustainable method of "greening" concrete with a net carbon negative industrial by-product. An attributional life cycle assessment with expanded boundary was employed to examine the life cycle global warming potentials (GWPs) of $1m^3$ of biochar concrete, containing wood-based biochar at 2%wt (i.e., by weight of cement). Carbon reduction is defined as the sum of the CO_2-equivalence that is "locked" in the biochar, avoided carbon emissions, CO_2 removal (due to Accelerated Carbonation Curing (ACC) of concrete and onsite carbon capture and sequestration (CCS)), reduction of concrete components' size, use of recycled aggregates and partially replacing cement with recycled pozzolanic materials (including limestone calcined clay concrete). Avoidance considered included CO_2 emission reductions due to the cement avoided (as a certain % of the total cement mass), incineration of wood waste in the incineration plant, and the avoided fossil fuel-based electricity required to run the pyrolyzer. In this talk, different scenarios in which various quantities of biochar - between 2%wt and 20%wt - is used in concrete (40 MPa), were examined and how all other factors must be addressed in order for carbon neutrality or even carbon negativity to be achieved.

NDCs in ASEAN Countries: Dreams or Reality? Case Studies: Indonesia and the Philippines

Dr. Linda Yanti Sulistiawati[1], Irene Amadea Rembeth[2]

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The Asia Pacific region has contributed approximately 83% to the global emission growth since 2010. Among the surge of emission in the Asia Pacific region, the ASEAN countries has been noted to have the highest growth rate – even globally. The region's trends and drivers are dominated by energy and AFOLU sectors. At the same time having significant emission growth, ASEAN Countries are among the most vulnerable and prone to be affected by climate change impacts. From such description, it can be said that ASEAN countries have the same interest in combatting climate change. As of 2017, all ASEAN countries had signed and ratified the Paris Agreement along with submitting their NDCs. Presently, most of the ASEAN members, have submitted their enhanced NDCs. Although enhanced NDCs displays progresses in national climate action, the pledges will never be effective unless they are actually implemented in the Country level. This research tries to depict local regulating efforts to reach those NDC targets in the local level of ASEAN countries, through examining the local government efforts in dealing with climate change issue and fulfilling their NDC targets. Also suggest alternative options to achieve NDC implementation in the local level of ASEAN countries, with case studies of Indonesia and the Philippines.

Conversion of Food Waste Derived Lipids to Bio-based Materials: Case of Polyurethane

Sunita Varjani

City University of Hong Kong, China

According to the Food and Agricultural Organization of the United Nations, 931 million tonnes of food waste is produced year by homes, stores, and the food service sector. Lipids, phosphates, carbohydrates, and amino acids present in food waste can be transformed into bio-based resources including chemicals, materials, and energy. In order to valorize food waste, there is an obvious need for the development of novel technologies. A sustainable chemical flow is being developed due to the present global agenda focusing on food waste management and its conversion to value-added products. Polymeric substances known as polyurethane (PU) have been reported for their application as adhesives, foams, sealants, coatings etc. Typically, polyols and isocyanates produced from petroleum are used to synthesize them. However, a shift towards renewable feedstocks as constituent raw materials has been sparked by the depletion of petroleum reserves, the increase in the price of petroleum, and the drive towards eco-friendly and sustainable feedstocks. In order to replace petroleum-derived polyols with bio-based polyols made from renewable resources like food waste, a lot of research work is being put into this. This study focused on investigating the characteristics and composition of food waste using standard methods. This presentation will cover important developments, challenges, and perspectives in lipid extraction from food waste, particularly emphasizing work done by our team on the subject.

Negative Emission Technologies: Engineered Carbon Removal Methods Within Puro Standard

Alvin Lee

Puro.earth, Singapore

In conjunction with global net zero aspirations, consensus is emerging that carbon dioxide removal (CDR) capacity in excess of five gigatons (5 GT) per year will be needed in the coming decades. Puro.earth was incubated by Fortum Oy and is supported by Nasdaq Inc. to mobilize the world's economy to reward negative emissions technologies. This session will explain the key underpinnings of the company's Puro Standard, which is an ICROA endorsed independent carbon standard, and which includes, thus far, five approved methodologies which enable carbon project developers to quantify their carbon dioxide removal volumes for the issuance of CO_2 Removal Certificates (CORC's) into the global voluntary carbon market: (i) biochar, (ii) terrestrial biomass storage, (iii) geologically stored carbon including DACCS and BECCS, (iv) carbonated materials, and (v) enhanced rock weathering. An overview of existing project developer activity in the above methodologies, by region, will also be presented.

The Power of Partnership: Forests for Global Net-Zero

Hyungsoo Kim

TREE PLANET, Republic of Korea

We introduce the establishment of the Net-zero Forest to raise awareness about the importance of the Earth's environment and protect the safety and recreational functions of global citizens and local residents from environmental pollution, including climate change. Through the creation of the Net-Zero Forest, our goal is to foster the development of local communities and establish a structure for active participation by global citizens.

REDD+ and Voluntary Carbon Market: A Review of the Relationship and Potential Implications

Yohan Lee

Seoul National University, Republic of Korea

An Increase in net-zero commitments by cooperates and governments has been accompanied by the growth of the voluntary carbon offset market, including Reducing Emissions from Deforestation and Forest Degradation (REDD+). REDD+ is an initiative that aims to provide financial incentives to developing countries to reduce greenhouse gas emissions from deforestation and forest degradation. The voluntary carbon market (VCM) is a platform where organizations and individuals can buy and sell carbon credits to offset their carbon emissions. This study examines the relationship between REDD+ and VCM, and explores the potential implications of their interaction. This study provides an overview of the voluntary carbon market and REDD+, including their goals, mechanisms, and challenges. Then, we discussed some critical issues to be addressed in implementing REDD+ program/projects such as additionality, non-permanence, leakage, double counting, property and community rights, and forest carbon financing. We suggest the potential implications of the interaction between REDD+ and the voluntary carbon market for different stakeholders, including developing countries, carbon market participants, and environmental organizations, and conclude suggesting areas in the Republic of Korea for further research and policy recommendations to enhance the effectiveness and sustainability of both REDD+ and VCM.

Biochar Research at CREATE E2S2

Chi Hwa Wang*, Yoke Wang Cheng

National University of Singapore, Singapore

Effective carbon sequestration technologies are highly sought over the globe in response to the global warming. Among various carbon capture technologies, thermochemical valorisation of lignocellulosic biomass wastes (mainly via pyrolysis or gasification) is deemed as a sustainable approach for solid waste volume reduction with the concomitant production of carbon negative biochar and bioenergy. Under Campus for Research Excellence and Technological Enterprise (CREATE) framework, National University of Singapore and Shanghai Jiao Tong University have jointly established a successful collaborative programme called Energy & Environmental Sustainability Solutions for Megacities (E2S2). Through the E2S2-CREATE programme, four fruitful case studies related to biochar utilization were presented to showcase the feasibility of biochar as partial growing media substitute and mortar additive. In the first study, the usage of wood waste pyrolysis biochar from South Korea as partial soil substitute did not improve the yield of pak choi but ameliorate its nutrients, as postulated by untargeted metabolomic analysis. In another independent study, the utilization of wood waste pyrolysis biochar from Singapore as partial soil substitute improved the pak choi yield, and the life cycle assessment proven the inclusion of biochar in cultivation greatly enhanced the net global warming potential reduction. Next, following the in-situ gasification of woody horticultural waste in the Gardens by the Bay, the raw and coarse gasification biochar were applied as partial peat moss substitute to cultivate vegetable crops (pansies, pak choi, and lettuce), whereas the fine gasification …biochar was used as cement additive for the production of non-structural mortar. Lastly, wood waste gasification biochar was utilized as partial compost substitute to grow sunflower under normal and elevated atmospheric CO_2 concentrations, and the seeds of sunflowers grown under elevated CO_2 levels met with the Singapore food safety regulations.

Certified IBI & EBC Biochar Production in Singapore

Tan Yong Tsong

Bluefield Renewable Energy Pte., Ltd., Singapore

Based on the current trajectory of GHG emissions it seems unlikely we can see a reversal of the increase in temperatures across the world. By 2030, in order to meet the CO_2 emission reduction targets, at least 23 $GtCO_2e$ are needed to be removed or captured. At present an average of 2 Billion tons per year has been removed and captured. Adding to this issue is the rise of carbon credits protectionism which may inhibit the cross-border transferability of carbon credits.

Bluefield Renewable Energy (BRE) is a Singapore based company that is positioned to support this effort to capture and store carbon, and to generate carbon removal credits for the markets that it operates in. It develops and owns its pyrolysis technology, and manufactures its systems in Singapore. BRE has deployed its first production line in Singapore to convert biomass into biochar and is certified by EBC and IBI, with its first batch of carbon credits transacted recently. In this session we will share some of the developments of biochar production in Singapore.

Microwave Processing: A promising Technique for Transforming Bioresources into Value-added Biochar Products

Su Shiung Lam

Universiti Malaysia Terengganu, Malaysia

Microwave processing involves the use of microwave heating technique in an inert environment that can break down and convert biomass and waste materials to produce useful liquid oil, gases, and char products. This technique has been applied for recovering the energy and chemical value of various types of waste materials, comprising forestry waste, furniture waste, fruit waste, waste cooking oil, agricultural waste, palm oil waste, etc. The technique shows advantages in providing a fast heating, relatively shorter process time and lower energy consumption, representing a method that is potentially faster and more energy efficient compared to that shown by the method commonly performed using conventional heating source. The microwave technique produces liquid oil product that can potentially be re-used as fuel to power the pyrolysis process, hence representing and promoting a circular approach for waste management, and the oil product is potentially cleaner with promising features to also be used as feedstock for bioplastic production. The microwave technique also produces solid products such as biochar and activated carbon that can be refined for use as adsorbent, solid fuel, and catalyst in pyrolysis process, which is also a potential route for circular waste management. The solid products also possess beneficial features for application in waste treatment. Our findings show that microwave processing shows potential as a promising approach with improved heating performance and generation of useful products with desirable properties for circular waste management. These have led to outputs such as joint research with international partners, patent filing, company licensing, journal publications, awards and industrial partnership for prototype development, distribution and application.

Towards Sustainable Agriculture: Biochar-Bacillus Consortium Reduces Fertilizers Dependency and Improves Oil Palm Seedlings Productivity

Rosazlin Abdullah*, Aaronn Avit Ajeng, Chuan Ling Tau

Universiti Malaya, Malaysia

Among the many uses for biochar in agriculture is its potential as a carrier for beneficial microbes. The majority of current research, however, has shown that a single bacterial species, rather than a group of microorganisms, may adhere to or immobilized on biochar for biotechnological uses. Response surface methodology (RSM) was used to conduct an optimization study on the operating and environmental factors influencing the bacterial adhesion, and the resulting soil stability and storage potential of the formulation, in order to evaluate the potential of oil palm kernel shell (OPKS) biochar as a biofilm-producing Bacillus consortium carrier. The maximal Bacillus population was found at 33 ˚C, 135 rpm agitation, 7.5 neutral pH, and 10% (w/w) sago starch as the co-carbon source. After optimization, the Bacillus adhesion to OPKS biochar matched pseudo-second order (PSO) kinetic modelling (R2 = 0.998). The Bacillus biofilm-adhered OPKS biochar (OPKSBBc) may be stored for up to 4 months with a minimum range of live Bacillus viability reaching 107 CFU/g of biochar, which is within the minimum range of acceptable biofertilizer viability (106 CFU/mL). This was discovered after the optimized formulation was subjected to storage at various temperatures and in vitro soil incubation.

Continue on next page

Towards Sustainable Agriculture: Biochar-Bacillus Consortium Reduces Fertilizers Dependency and Improves Oil Palm Seedlings Productivity

Rosazlin Abdullah*, Aaronn Avit Ajeng, Chuan Ling Tau

Universiti Malaya, Malaysia

Formulation that is viable in room storage can be easily incorporated into current agricultural distribution networks that do not have refrigeration. The randomized complete block design (RCBD) glasshouse design was also set up to test the applicative impacts of the developed formulation on 3-month-old … oil palm (Elaeis guineensis) seedlings grown on infertile soil for a duration of 6 months with the following treatments: T1: Control, T2: 100% chemical fertilizers (CF), T3: 100% OPKS biochar, T4: 100% Bacillus spp., T5: 100% OPKSBBc, T6: 50% OPKSBBc + 50% CF and T7: 30% OPKSBBc + 70% CF. According to the glasshouse experiment, the 30% application rate of OPKSBBc may minimize the use of chemical fertilizers in the oil palm seedlings nursery because the growth of seedlings was averagely equivalent to the treatment using 100% chemical fertilizers. When compared to the control, the combination of 30% OPKSBBc rate supplemented with chemical fertilizer boosted seedling growth by 28%, girth diameter by 9%, and chlorophyll index by 33%. The N, P, and K content of the seedlings vary, with 100% CF having the most N content, OPKS biochar having the greatest P content, and 30% OPKSBBc having the highest K content. The soil nutrient status varies, with 30% OPKSBBc having the most P, 100% OPKSBBc having the greatest N, and 100% CF having the highest K.

Attitudes Toward Climate Crisis: A Consumer Socialization Framework

Youngju Jung

Korea University, Republic of Korea

Every corner of people's life has been affected by ecological changes, and the presence of changes is becoming more evident than ever. Extant research has taken interscholastic approaches to disclose underlying mechanism in encouraging people to lead eco-friendly lifestyle, yet limited research was conducted to examine the effects of social and demographic factors on pro-environmental behavior. The current study adopted consumer socialization framework (Ward, 1974) to investigate on how demographic characteristics interact with social and environmental attitudes to induce relevant behavior in the context of pro-environmental. A total of 546 participants were recruited for an online survey, which consisted of items measuring demographic factors as well as attitudes towards social, media, and environment. Findings suggest that media consumption and peer communication regarding environmental issues, the core fundamentals of socialization process, significantly impact pro-environmental behavior, along with such demographic antecedents as age and income. The mediating role of environmental efficacy was also revealed in establishing pro-environmental behaviors. The results offer both theoretical and practical implications by providing a framework in assessing social and demographic factors to increase constructive behavior in improving environmental conditions.

Sustainable Consumption: Reducing Food Waste in Restaurants

Jungwon Kim

Korea University, Republic of Korea

Sustainable consumption and production have become more important than ever to prevent environmental destruction. It is notable that food waste constitutes more than one-third of the waste, roughly 75% of which is still edible. The current study aimed to find out more effective strategies to persuade consumers to engage in waste reduction behavior. Specifically, we examined the message effectiveness of descriptive norms with emotional appeals. Descriptive norms are one of the social norms which communicate how individuals actually behave and motivate individuals by making them conform to the desirable behaviors of others. The results showed that the average food waste for persons in the minority descriptive norms messages with guilt appeals condition was significantly less than the average food waste for persons in control condition. The results of this study increased the theoretical understandings of message persuasiveness of minority descriptive norms and provided managerial implications for leading consumers' green behaviors.

Sustainability in the Hospitality

Soyeon Park

Korea University, Republic of Korea

As the importance of sustainability continues to grow, the hotel industry is implementing various pro-environmental practices aimed at reducing its negative impact on the environment. Implementing these practices without considering consumers' perceptions may have unintended negative consequences. Although consumers value sustainability, they may show somewhat negative reactions to such practices due to inconvenience and ineffectiveness. The current study employs sequential exploratory mixed methods aimed to identify and investigate the factors that may contribute to consumers' negative attitudes towards green hotel. The results showed that absence of benefits, perception of greenwashing, helplessness, quality concern, image incongruity, and indifference were negatively related to consumers' reactions to green hotels. By taking into account these factors, hotels can work towards a more sustainable future while still meeting the needs and expectations of their guests. This can impact the success and effectiveness of these practices in achieving sustainability goals.

Impact of Pharmaceuticals on Healthcare and Environmental Costs

Sui Yung Chan, Poh Leng Tan, Qi Shan Chua

National University of Singapore, Singapore

The shifts in disease patterns, as a consequence of our ageing population, will drive changes in the organization and delivery of health services, as well as the cost of services and treatment. Some types of medicine have especially high carbon footprints. The health systems can identify where to make reductions by mapping the carbon footprints of medications, according to dosage forms, to national consumption. Healthcare professionals can band together and implement the strategies, solutions and services that will deliver resilient and sustainable healthcare for our current patients and the generations to come. There is a need for healthcare professionals' collective expertise, innovation capability and shared understanding of the need to drive systemic change to implement sustainable practices combined with safe, efficient, and effective pharmaceutical products to improve health outcomes, lower cost to health systems, and enhance patients' and staff's experiences.

Film medicines as alternative planet-friendlier (yet effective and safe) pharmaceutical products in following aspects: 1. Production of film medicines compared to the production of tablets, capsules and injections has lower carbon footprint as there are fewer processes, smaller quantities of few excipients with less energy consumption.

2. Use of film medicines do not require dosage delivery devices and bulky containers. a. Elimination of production, transport, storage and distribution of dosage delivery devices; b. Save some healthcare professionals' time for explaining and showing patients and/or caregivers how to use them; c. Reduction of medical and biohazard waste as majority of these devices are meant for single-use and are not recyclable.

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Impact of Pharmaceuticals on Healthcare and Environmental Costs

Sui Yung Chan, Poh Leng Tan, Qi Shan Chua

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3. Film medicines will reduce the burden of nurses and caregivers looking after patients who cannot swallow solid medicines and/or are on tube-feeding. Replacing the frequent practice of crushing tablets and opening capsules, obtaining the powdered medicines before mixing the powder with syrup, beverage, soft food or into water to tube-feed patients. a. Replacement of manufacturing of tablets and capsules which are then reduced to powder forms before giving to some patients.

This will save energy and investment (facilities) by fewer production and quality testing processes, less need for heavy-duty equipment, reduced excipients (fillers, binders, sweeteners). b. Elimination of stocking, using and cleaning mortars, pestles, crushers of solid medicines; c. Reduction of contamination during preparation and elimination of administration errors, inaccurate dosage and wastage due to or spillage incomplete consumption of the liquid or food containing crushed medicines. d. Elimination of steps for giving powdered medicines suspended in liquid to patients on tube-feeding.

The tubes are frequently blocked by the powdered medicines. Patients will have to wait for blocked tube to be replaced (requiring x-ray to confirm tip of tube is in stomach, not lungs) before they can resume tube-feeding of milk nutrition and medicines. e. Avoidance of needle-stick injuries with associated trauma, medical leave and treatment for injured persons. f. Reduction of frequent production and replenishment of compounded liquid medicines which have short shelf-lives of 14 days or a few with 28 days as film medicines have longer shelf-lives similar to tablets and capsules as their water activities are low.

Continue on next page

Lignin in Biochar Dissolved Organic Matter to Inhibit Microplastic Aging: Free Radical Mechanism and In Vivo-In Vitro Biotoxicity Analysis

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Microplastics (MPs) have emerged as a novel and highly concerning contaminant that is ubiquitous in the aqueous environment. However, the aging behavior of MPs with the involvement of dissolved organic matter (DOM), especially biochar-derived dissolved organic matter (BDOM), and the biological toxicity after aging are not fully understood. In this study, BDOMs were derived from biochars by pyrolyzing of pine wood chips at 200-900˚C, respectively, and differences of BDOM were investigated via ultraviolet–visible spectroscopy, excitation-emission matrix fluorescence and Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS). The effects of BDOM participation on photoaging and biotoxicity of MPs were investigated by determining the morphology, particle size, functional groups and radical changes of MPs as well as in vitro-in vivo biotoxicity experiments using micron polyethylene (PE) as an example. The results showed that BDOM contained a higher proportion of lignin, aliphatic/peptides, lipids and the least amount of condensed aromatic hydrocarbons. With the gradual increase of pyrolysis temperature, the aromaticity and fluorescence intensity of BDOM decreased but the molecular weight increased. BDOM rich in lignin-derived chromophores can enhance its light absorption and photo-responsiveness, thus enhancing its light-shielding effect. The results of EPR analysis confirm that BDOM addition makes the ·OH production of BDOM/PE system reduced, i.e., BDOM can inhibit ·OH production through light-shielding effect, but BDOM in turn facilitates the long-term stable ·OH production of the system.

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In addition, the involvement of BDOM makes the light higher degree of fragmentation and morphological changes on the aged PE surface, which facilitates the oxidation of the lower PE layer. The increase of O/C on the surface also indicates that the addition of BDOM promotes the photoaging of PE. However, the addition of BDOM and prolonged irradiation did not cause significant changes in PE particle size, i.e., no significant aggregation or fragmentation into smaller pieces. Similarly, only an increase in the intensity of hydroxyl groups was observed in the FTIR patterns, and no new functional group carbonyl groups were present, indicating that the oxidation of PE only proceeded to the propagation reaction to generate hydroxyl groups, and no subsequent chain-breaking or cross-linking reactions occurred to generate specific oxygen-containing functional groups such as aliphatic carboxylic acids, aldehydes and ketones. It is speculated that this is due to the susceptibility of lignin to photodegradation and possible competition with PEs for -OH to inhibit the aging of PEs. Furthermore, in vivo-in vitro biotoxicity studies of MPs showed that photoaging PE with the involvement of BDOM greatly improved systemic inflammation and reduced cell death although it decreased cell activity. Overall, the involvement of BDOM, while favoring the long-term stable ·OH production of the system, does not significantly promote the photoaging of MPs. The results of this study contribute to an in-depth understanding of the environmental behavior of BDOM and MPs systems.

Effects of Key Properties of Rice Straw Biochar on its Microbial Resistance Stability: Insight into Dissolved Organic Carbon, Pore Structure, and Persistent Free Radicals

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Biochar is considered a promising material for carbon sequestration owing to its high stability. However, the effects of biochar properties, especially dissolved organic carbon, pore structure, and persistent free radicals (PFRs) on its microbial resistance stability (MRS) remain unclear. Incubation experiments were conducted to investigate the anaerobic and aerobic MRS of rice straw biochar produced at 300–700 ºC with and without vermiculite modification, and to evaluate the relationship between biochar key properties and its MRS. The results showed that the signal intensity of PFRs in biochar was much higher under anaerobic conditions than that under aerobic conditions, increasing with temperature from 300 to 600 ºC, but sharply decreasing at 700 ºC. Anaerobic MRS of biochar produced at 700 ˚C was lower than that at 300–600 ºC, indicated by the higher CH4 emission. Redundancy analysis indicated that there was a significant correlation between the cumulative CH4/CO2 emission and biochar properties. PFR concentration negatively affected the cumulative CH4 emission with a correlation coefficient of –0.467, and thus could be considered as the most critical factor affecting the anaerobic MRS of biochar, followed by pore volume and specific surface area with a correlation coefficient of 0.405 and 0.281, respectively. Dissolved organic carbon and pH of biochar were the most important two factors affecting its aerobic MRS according to their high correlation coefficients (0.933 and –0.848) with cumulative CO2 emissions. Vermiculite modification enhanced MRS and accordingly lowered the global warming potential of biochar produced at low temperature (300–500 ˚C) by 4.59–20.2% and 15.3–42.9% under anaerobic and aerobic conditions, respectively. However, it had contrasting effects on biochar produced at high temperature (700 ˚C). We deduced that the application of biochar in paddy fields would be more effective for global warming mitigation compared to its application on dry land.

Beyond Carbon: The Critical Role of Dissolved Black Carbon in Biogeochemical Processes

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Dissolved black carbon (DBC) is the water-soluble fraction of the black carbon continuum and the key flux that connects two major black carbon pools: the soils and the ocean sediments. DBC is also an important component of dissolved organic matter and plays an important role in the environmental transformations of minerals and pollutants. We systematically investigated the environmental activity and reactivity of DBC, founding that: (1) DBC could trigger decomposition and transformation inhibition of antibiotic resistance genes in aqueous environments; (2) DBC after heteroaggregating with Fe-oxides could greatly mediate the phase transformation of Fe(III) (oxyhydr)oxides; and (3) DBC could modulate the formation of iron plaque through facilitating iron-involved redox reactions on aquatic plant root surfaces. These findings provide new insights into the behaviors and implications of DBC in the dynamic environments.

A Pilot Study of Arsenic Removal from Water by Biochar Electrodes

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Arsenic, which is abundant in nature, is an element with a gray luster and has both metallic and nonmetallic properties. Arsenic pollution is mainly caused by As(III) and As(V), and As(III) is more toxic than As(V) and is more susceptible to oxidation. The rapid development of human society has resulted in the abundance of arsenic in natural waters. To date, several methods have been proposed to remove arsenic according to different situations: coagulation, biological treatment, ion exchange, adsorption, membrane treatment, etc. Cost, efficiency, and secondary pollution are the challenges that these technologies need to face. It is of great significance to seek new methods that are green, efficient, and economical. In this study, a new approach that using biochar electrode for arsenic removal was proposed, which reduces the cost and ensures the principle of environmental protection. When the concentration of arsenic was 0.05 mg /L, the adsorption efficiency of biochar was 12.8 %. At low concentration, the adsorption of arsenic by biochar conforms to the H-type adsorption isotherm. Under the same conditions, when a 10 V voltage was applied, the adsorption performance of biochar was significantly enhanced to 24.3%. Even when the applied voltage was increased to 30 V, the removal efficiency of arsenic reached 61.2%. The adsorption of arsenic by biochar was obviously improved by applied electric field. This may be due to the concentration of arsenite ions towards the anode under the influence of electric field, which increases the concentration gradient, thus increasing the adsorption rate of biochar. Moreover, the positive charge on the surface of anode biochar increases its adsorption affinity to anions, thus increasing its adsorption capacity. Therefore, the application of biochar electrode to remove arsenic from water is a new idea worthy of attention.

Effects of Phosphorus-modified Biochar on Soil Remediation and Plant Growth in Soil-plant Interactive System

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Biochar, a type of soil amendment, is stable carbon-based biomass produced in the absence of oxygen to more than 250℃. Due to its potential for carbon sequestration and its environmentally friendly nature, the application of biochar has gained increasing attention on a global level in recent years. To address the worldwide concern about phosphorus (P) deficiency in agricultural soil, biochar is modified by phosphorus, leading to the increased P availability and improved soil quality when it is applied in soil. This study aims to investigate the effects of P-modified biochar as a soil amendment on soil remediation and plant growth in soil-plant interactive system. Plants (Pseudostellaria heterophylla) were grown for 4 months in lateritic soil amended with P-modified and unmodified biochar (peanut shell) at dosages of 0, 3% and 5% (by mass). Each condition has twenty-one seedings in three replicated pots. The soil properties including heavy metal availability, nutrient levels and water retention ability were measured to evaluate the soil quality and the remediation efficiency of biochar. Leaf area and root morphology of plants were monitored to analyse the plant growth promotion affected by various biochar amendments. Moreover, the microbial community in rhizosphere soil were determined to assess the soil health at harvest. The results of this study could supply the basis and recommendation for high-efficient soil remediation and improved soil ecosystem by way of P-modified biochar application.

Mitigation of Humic Acid Electron Competition Inhibition by Biochar during Anaerobic Digestion: Enhancing Syntrophic Acetate Oxidation with the Role of Electron Hopping Mediator

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Biochar has been shown to enhance microbial extracellular electron transfer during the negative carbon emission technologies anaerobic digestion (AD), but its ability to mitigate the electron competition by humic acid (HA) is unclear. In this study, we focused on the electron carrier function of biochar to investigate its effect on electron transfer in inhibited AD systems by HA. The mechanism of the electron transfer interface and its effect on the metabolic pathway was analyzed. The results from isotope labeling experiment showed that the biochar could achieve the conversion of the methanogenic metabolic pathway from the aceticlastic methanogenesis to the syntrophic acetate oxidation (SAO), and thus the electron competition inhibition by HA was alleviated. Electrochemical and Microscopy analysis showed that microbial attached to the biochar surface undergo electron transfer via cyt-c and riboflavin in extracellular polymers. Theoretical calculations and molecular dynamics simulations verified the feasibility of biochar as an intermediate medium for electron hopping processes. Metagenomic and metaproteomic sequencing analyses also revealed that the conversion of metabolic pathways from the aceticlastic methanogenesis to the SAO. Accordingly, this research believed that the biochar could mitigate the HA electron competition inhibition by enhancing SAO with the role of electron hopping mediator.

Green Conversion of 5-hydroxymethylfurfural to 2, 5-furandicarboxylic Using Graphene Based Nitrogen-Doped Carbon Catalyst

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Unsustainable environmental practices such as the production of chemicals and their derivatives using the existing fossil fuel reserve have resulted in the elevation of global temperatures. Thus, it is paramount that we explore green practices to circumvent this issue. Recently, biomass valorization has presented itself as a sustainable solution. Through acid dehydration of sugars, biomass can be converted into platform chemicals such as 5-hydroxymethylfurfural (HMF) which upon further oxidation can be transformed into 2,5-furandicarboxylic acid (FDCA). FDCA can be used as a monomer for the production of bioplastics. Although metal-based catalysts for selective conversion of HMF to FDCA have been reported to be highly effective, it is often accompanied by problems of deactivation and leaching. Hence, the research focus has shifted toward metal-free catalysts. Among these, the performance of nitrogen-doped carbon catalysts has been extensively evaluated as it is an efficient and inexpensive catalyst owing to the presence of various heteroatom substitutions in its carbon matrices such as pyridinic N, pyrrolic N, and graphitic N which aid in FDCA production. It is reported to be active under harsh reaction conditions involving organic solvents, strong bases, and high reaction temperatures. In this study, we have designed a promising nitrogen-doped carbon catalyst using graphene oxide (GO) and biopolymer chitosan. This catalyst demonstrated superior performance as compared to the conventional nitrogen-doped carbon catalyst displaying 99% HMF conversion with 62.2% yield of FDCA in water at 120ºC in the presence of a mild base at the end of 10 h reaction time. GO along with chitosan in the catalyst resulted in the formation of several new active sites that aided in the selective aerobic oxidation of HMF. Complying with the principles of green chemistry, graphene oxide-based nitrogen-doped carbon catalyst presents itself as a highly efficient catalyst for the production of FDCA in water.

The Role of Biochar in the Environment

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Biochar is a versatile carbonaceous material obtained through pyrolysis of various organic materials in the absence of oxygen. Agricultural/garden waste, forest waste, industrial waste, and municipal waste are among the main sources of raw materials for biochar production. Converting waste into biochar through pyrolysis is an effective way to reduce waste volume and recover energy and resources. With its high porosity and large specific surface area, biochar has excellent adsorption capacity, biodegradability, and environmental friendliness, making it a popular choice in agriculture, environmental protection, and industry. One of the significant benefits of biochar is its ability to enhance soil quality by improving soil permeability, water retention, fertility, and promoting plant growth and ecological balance. Additionally, biochar can reduce soil and water pollution by reducing the migration of heavy metals and organic compounds. Biochar also serves as an effective adsorbent to remove pollutants from water and air, reducing their environmental hazards. Biochar has multiple applications in industry, including adsorption, catalyst carrier, electrode, energy, and construction materials. In conclusion, biochar is an environmentally friendly, multifunctional material that holds great promise in soil improvement, pollutant adsorption, waste treatment, energy recovery, and ecological restoration.

Understanding the Different Ageing Process on Colored and Non-colored Polypropylene Microplastics

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Mishandled plastic wastes lead their way into different environments as tiny plastics known as microplastics (MPs). MPs can be either primary, which are intentionally produced for their application or secondary, released as a result of physical, chemical and biological fragmentation and degradation of macroplastics. Among the various disintegration processes physical stress, UV irradiation, thermal ageing, and chemical oxidation are found to be the common phenomena that take place. These processes can further change the properties of MPs based on several factors. All these circumstances make these tiny plastics more persistent and highly toxic which can further get migrated longer to other environments and act as a vector for various pollutants and microbes due to their unique characteristics. Previous research works mostly studied the changes that happens in different polymer types in several natural and artificial ageing processes. But still, there is a lack of understanding of the transformations that happens with different materials of the same polymer type. Additives also plays a key role in interfering in the ageing process that exists in a plastic material along with the base polymer. So it is particularly important to study the MPs behaviour, ageing and transformations of different materials of same polymer type to understand its further response.

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So it is particularly important to study the MPs behaviour, ageing and transformations of different materials of same polymer type to understand its further response. Polypropylene (PP) is one of the major types of polymer that are being used in many commercial products. They are found to be highly detected MPs type in most environments. So we have chosen two types of PP materials for this study, (a) PP non-colored straw (PPS) and (b) PP colored straw (PPSc). Thus the major objective of this study is to understand the different ageing mechanisms of PP MPs under varying phenomena such as fenton oxidation (chemical), heat treatment (thermal) in air and UV irradiation in seawater. This work gives in-depth understanding on physiochemical changes in the different PP MPs with varying ageing conditions, and its further possibility in the uptake of pollutants. Also, it gives a view of the major role of additives that intervenes in the above-mentioned process and their respective changes in properties.

From the study, it was clear that UV ageing made predominant changes in the PP MPs when compared to other ageing treatments, followed by chemical and thermal oxidation . Compared to PPSc, PPS were found to be aged more due to the presence of pigments in PPSc which may act as a protective layer. The ageing process is found to permanently alters the physiochemical and mechanical properties such as the formation of new functional groups as a result of oxidation, crystallinity, strength, colour, formation of wrinkles and cracks along the MPs surface and which results in the fragmentation of MPs to even smaller ones. The degradation process can further release the polymer monomers, oligomers and additives and can aggravate the pollutant concentration in their respective environments. These weathered MPs can uptake higher concentrations of other prevailing pollutants than compared to the pristine MPs.

Potential of Enhancing Carbon Neutrality Goals by Water Quality Prediction with Machine Learning: A Case Study of River Stream

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Water cycle is a crucial process in the ecosystem, playing a significant role in carbon cycling and transportation. However, it requires a considerable amount of energy input to sustain the entire process of water intake, transportation, discharge, treatment, and reuse. Improving the efficiency of each stage of the water cycle can significantly reduce carbon emissions and contribute to achieving carbon neutrality goals. Rivers are vital sources of water and an indispensable part of the water cycle. Therefore, monitoring and predicting water quality trends can provide essential information for the entire water cycle. In this study, machine learning algorithms were employed to predict the water quality index (WQI) of Jinwi River in South Korea. The predictive models were trained using a dataset of nine water quality indicators, and three models, including Random Forest, Extreme Gradient Boost, and Gradient Boost, were evaluated for predictive accuracy. The results indicate that Gradient Boost outperforms the other two models, demonstrating a high accuracy (R = 0.991) and low error (MSE = 2.63). Future research may focus on expanding the data range and developing more sophisticated models to predict water quality trends accurately, providing essential insights for optimizing the water cycle and reducing carbon emissions.

A Study on Production of Turquoise Hydrogen According to Carbon Adsorption in Biochar

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Recently, interest in carbon capture and storage (CCS) technology is increasing as interest in carbon neutrality and alternative energy hydrogen has increased due to greenhouse gas and climate change problems. All of them, biochar is one of the carbon sequestration methods that can solve that problem. This study confirmed the change about the cracking of hydrocarbon fuel injected into biochar through the developed F3-tech system (Flat Flameless Furnace technology). Biochar produced by high-temperature pyrolysis of biomass was carried out in a batch-type indirect pyrolysis method through the F3-tech for uniform temperature distribution in the furnace. Biochar produced BOG (Biochar Oven Gas) through cracking of hydrocarbon fuel and carbon adsorption. The experiment confirmed the composition of BOG according to temperature and input fuel and the change in carbon adsorption of biochar according to time. It was confirmed that the BET of biochar was lowered through carbon adsorption, and hydrogen was about 60% of the produced BOG.

Sustainable Removal of Hg and NO_x in Coal Fired Power Plant

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Elemental mercury (Hg0), which is produced by burning coal in thermal power plants, has low solubility in water and high volatility, so it is not easily removed by air pollution control facilities and is discharged into the atmosphere and adversely affects the environment and ecosystem. Emissions of mercury are regulated worldwide by the 'Minamata Convention on Mercury', and in order to comply with this requirement, many researchers investigated a method of removing Hg0 by spraying activated carbon into flue gas and proved its excellent efficiency. In this study, mercury capacity was measured through sulfur functionalization under various conditions using cheap biochar for more efficient and economical removal of elemental mercury. Bio-char (Yougi biochar, Yougi Ind Co., Ltd) made by carbonizing rice hull at 400–500 ℃ was used as an adsorbent, and sulfur functionalization was performed using a batch-type special reactor designed in the laboratory to increase the chemical sorption capacity for Hg0. This reactor, which can minimize the loss of the material to be supported, can re-adsorb gas of H_2S or SO_2 generated by high temperature into biochar. During sulfur functionalization, the effect of biochar synthesis conditions on the adsorption of Hg0 was investigated by varying the sulfur content, thermal treatment temperature, thermal treatment holding time, and oxygen content. Each manufactured biochar was subjected to XPS, SBET, elemental analysis, and FT-IR to confirm the physical properties and functional groups.

Study on Carbon Absorption and Hydrogen Production Characteristics Using Biochar Oven with Biomass

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Biochar is attracting attention as a technology for storing greenhouse gases in the atmosphere. The biochar oven, which undergoes a high-temperature pyrolysis process of 900 degrees or higher, converts the CO_2 absorbed by biomass into dense and stable solid carbon, and at the same time produces gas fuel containing a high concentration of hydrogen, so there is no cost for CO_2 separation / treatment. Rather, it is an economical technology that can supply high-quality carbon materials and hydrogen energy. In this study, the possibility of commercialization was confirmed through experimental results and process analysis of batch, semi-continuous, and continuous biochar ovens for various biomass. The higher the temperature of the biochar oven and the higher the height of the biochar layer in the reactor, the higher the hydrogen concentration of the pyrolysis gas discharged, confirming the production of hydrogen-containing gas. On the surface of the produced biochar, the carbon adsorption process of the pyrolysis gas occurs and is converted into nano-carbon fibers or crystalline form, and most of the pyrolysis gas is converted into hydrogen, methane, CO, etc. through this process. Biochar ovens with these characteristics can use generated gas fuel as biochar oven heating energy and supply surplus gas to the outside. It can be expected that the efficiency will increase by applying the heat recovery process.

Remotely Operated Vehicle and Passive Sampling Techniques for the Sustainable Management of Contaminated Sediment

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Introduction: Sediments receives various contaminants, such as nutrients, heavy metals, and persistent organic pollutants, from watershed, and becomes the environmental medium that transfers the contaminants to aquatic organisms and to overlying waters. Hence, managing contaminated sediments is critically important in keeping aquatic environments and ecosystems healthy and safe. However, sediments are generally posed in waters with depth raging from 10-100 meters in large reservoirs in South Korea and investigating the sediments have been challenging and costly. In addition, scuba divers are sometimes required for sediment investigation, and risks are always present relevant to the deep-water diving. Safer, more cost effective, and more technology and science-based investigation is necessary for sustainable management of contaminated sediment.

Method: In the present study, 40 kg weighing remotely-operated-vehicle is developed for sediment investigation. The ROV is able to take grab surficial sediment samples as well as 20 long core samples. A robot arm is integrated into the ROV, and the arm can hold diffusive gradient in thin film passive samplers and insert into the sediments in situ. The DGT stays in the sediment to take porewater samples for various nutrients, heavy metals, and POPs.

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Results: The ROV for contaminated sediment investigation is being applied to Andong reservoir in Korea, which has contaminated sediments from past mining activities in the watershed. The ROV showed that ~ 1 kg surficial sediments can be taken by grab samplers, and 20 cm long sediment core in-situ. Currently, DGT passive samplers are being deployed in the 50 m deep water sediment.

Conclusion: In the present study, ROV for sediment investigation is developed, and being applied to sediments in 50 meter deep reservoir. This technology will minize the risk associated with scuba diving and will be cost effective and sustainable. In addition, passive samplers are integrated with ROV and this allows us to measure porewater contaminants in-situ. This will provide us more integrated and relevant contamination data and will suggest more science-based site information for sustainable decision making.

An Integrative Review of ESG in Healthcare and Nursing

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Introduction: Healthcare and nursing are one of the professions that have a close relation with environment, social, and governance (ESG). The importance of applying ESG principles in healthcare field is growing, thus healthcare professionals need to consider the sustainability of healthcare, as well as the delivery of nursing practice. However, little is known about how the ESG principles were applied among healthcare fields and nursing practice. Thus, this integrative review sought to summarize what is currently known about the ESG and healthcare including nursing, and to identify directions for future research.

Method: The methodology for this research was based on the guidelines presented by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). The necessary search was conducted in PubMed, CINAHL, Web of Science, and Embase databases. To be eligible for inclusion studies had to associate Environmental, Social, Governance (ESG) or Sustainable Development Goals (SDGs) with nursing or healthcare. The search identified 23,759 studies and 4 additional records through other sources were added. After the studies were assessed for eligibility, 18 studies were included.

Results: Among the 18 articles, ten articles described the healthcare organizations' role for adopting and embracing ESG principles and the outcome of improved performance. … Three articles were specifically related to nursing and ESG, such as the importance of using ESG principles within nursing in order to incorporate sustainable action within the healthcare. The last articles were discussed on various topics, such as the ESG performance in the pandemic situation or climate change and urban population health.

Conclusion: Therefore, the healthcare and nursing practice should be constructively aligned to the ESG principles. Furthermore, the education of healthcare and nursing need to reflect sustainability such as universal health coverage, inequality, climate change, and gender equality, to overcome the current challenges in healthcare field.

Accelerating the Development Of SMEs and Their Adaptation to Circular Economy Models and ESG Reporting: Spin Project in Poland

Agnieszka Joanna Nowaczek*, Ewa Zofia Dziobek, Joanna Kulczycka

Polish Academy of Sciences, Poland

Knowledge and eco-innovation are the engines of sustainable economic development. The SME sector (micro, small, and medium-sized enterprises) constitutes the vast majority of companies in Poland - 99.8%, and at the same time, it is considered the least innovative. Even, though the financial and economic aspects are crucial in their decision, and eco-innovative solutions prove to be very costly, the number of SMEs looking for and implementing ecological innovation is growing, especially when the innovation generates environmental and business benefits. To promote eco-innovation in national and regional strategies there is a wide variety of instruments and projects to support SME investment and transformation. An example of a project helping entrepreneurs who are active in regional smart specializations is SPIN - Knowledge Transfer Centers (KTC) in Malopolska Region in Poland. Malopolska has a high potential in the field of scientific research and higher education - Kraków is the second research and development center in Poland and one of the leaders of eco-innovation according to the Eco-index developed by Bank Millennium. To keep and increase eco-innovation in the region, closer cooperation between science and SMEs is supported. SPIN enables the transfer of innovative solutions from scientific units and institutions servicing business to the company, reducing the competence gap and resulting in improving the position on the market and gaining a competitive advantage. Starting in 2016 over 750 entrepreneurs have been supported with innovative ideas and 1250 services have been provided free of charge by scientific institutions.

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SMEs can choose from 3 available, tailor-made services: a pre-audit covering the overall performance of the company, an in-depth technological audit assessing the entrepreneur's potential and environment, and consulting services in the field of technology transfer. Since this form of cooperation turned out to be a success, and the circular economy and Eco-Malopolska are important elements of the regional policy, the next edition of the project is planned, focusing on Environmental, Social and Governance (ESG) and training in this field. This is due to the growing requirements in supply chains and greater awareness of SMEs about the importance of non-financial reporting in the further development of companies. A more detailed description of the SPIN project and its results will be provided.

Boosting Confidence in Biochar Product Value for Carbon Removal and Multiple Co-benefits: An Australian Perspective

Sirjana Adhikari*, Ellen Moon, Wendy Timms

Deakin University, Australia

Biochar products face several uncertainties and challenges that are likely to hinder consumer confidence and may inhibit the large-scale use of biochar that could otherwise benefit environmental sustainability. Biochar market growth could be enabled by reduced costs ($/tonne), increased production volumes (tonne/year) with an ultimate target of ~20% of the global carbon removal and carbon offset markets accounted for by biochar. Our research objective was to identify challenges for the large-scale use of biochar as a soil improver. Several commercial biochar samples were characterised, and their properties considered from the perspective of consumers in horticulture and agriculture. Biochar products were characterised for acidity and salinity (pH, EC), surface properties for nutrient holding and delivery (CEC, surface area), elemental analysis (C, N, O content) , proximate analysis (%C, ash, VM), carbon stability analysis, water holding capacity analysis, and organic chemical composition (FTIR spectroscopy). Biochar products were then classified and ranked as a guide to consumers for specific soil applications (or risks to soils), for example, biochar properties suitable for providing nutrients to crops. Most commercial biochar products were found to be suitable for many soil applications. However, there were instances were individual biochars were not suitable for specific applications. However, there were instances were individual biochars were not suitable for specific applications.

Continue on next page

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For example, due to its neutral pH, low water uptake and high H:Corg ratio hardwood biochar (<500˚C) (product L-HW4) is not suitable to be used in acidic soil for the purpose of enhancing water storage and for long term carbon sequestration. Also, biochar from mixed feedstock (biochar product L-MF3, 500-550˚C) in a continuous pyrolysis plant is not suitable for fertilizer co-benefits (e.g. CEC) because of its low CEC compared to other biochar products. Furthermore, biochar from mixed feedstock (L-MF5 550˚C) may be a risk for saline soil, due to its high salinity.

These exceptions highlight the need for at least baseline analyses of a broader range of biochars before suitability for specific applications can be determined. From a consumer's perspective, use of biochar and its acceptance is hindered by current high costs, challenges in broad-scale application to soil, and how readily and rapidly the multiple benefits of using biochar can be observed. Local biochar is currently expensive (AUD3000 to AUD48,000 per tonne) due to the typically small quantities produced for boutique markets in Australia (e.g., organic gardeners). However, the properties of the biochar products that we tested ranged very significantly, and thus production design could be focused on specific soil applications (e.g., water holding in sandy soils). An evidence base for benefits and risks of different types of biochar products clearly communicated can improve governance for broad-scale biochar applications and ensure environmental protection. Case studies demonstrating the costs, reliability, and co-benefits of different types of biochar products are needed scale-up production and use of biochar. Industry standards such as IBI, EBC, ANZBIG (e.g., including 3-tiered use classes) for biochar products are a positive development, although refinements and expansion of these standards, along with consistent product labelling could also boost biochar markets.

Sustainable Removal of Methane by Methane Oxidation Bacteria from Arctic Subsea-floor Sediments Using a Sequencing Batch Bioreactor

DongGyun Seo, Dhiraj Kumar Chaudhary, YongSeok Hong

Korea University, Republic of Korea

Methane is considered the second most important greenhouse gas in the atmosphere. Permafrost thaws in the arctic region are known to have the potential to increase the atmospheric methane. However, soils can be a significant sink for methane through the removal by methane oxidizing bacteria (MOB or methanotrophs) where methane is utilized as carbon and energy sources. In this study, we aim to examine the diversity of MOBs in the arctic sediments and their ability to remove methane. The diversity of MOBs were identified by relating gene sequences to a specific phylum of MOBs. Sequencing batch reactor was set up and run to determine the removal efficiency of methane by MOBs. From the gene identification, it was found that there were two phyla of MOBs, which are Verrucomicrobia and Chloroflexi, each accounted for 63.8% and 36.2% respectively. As for the removal efficiency, the 2% of methane is removed in the bioreactor and removal rate is increasing slightly, reaching 4% removal in week 8. Overall, presence of MOB in arctic sediments was confirmed, and the removal efficiency was found lower than the theoretically calculated one. Future study should investigate the reasons for this discrepancy to reveal possible other mechanisms that may have been involved with.

Development of Gold Amalgam Voltametric Microelectrode for the Quantification Of Mn^{2+}

Hyunsoo Jo

Korea University, Sejong campus, Republic of Korea

Manganese is applied to various industries such as fertilizer, manganese compound manufacturing, dyes, paper manufacturing, ceramics, and pharmaceuticals, and has recently attracted attention as a battery material. Manganese which is eluted from these processes can be toxic to humans, so we need a method of measuring the exact concentration of manganese. Generally, when measuring manganese in rivers and lakes, most of them analyse the concentration using the ex-situ method. This method takes lots of time and manpower for analysing sediments of rivers and lakes. To solve this problem, use of a voltameter on site at different depths of sediments in river was considered instead of doing an ex-situ analysis. A microelectrode made of gold-amalgam was developed as a working electrode, and the square voltammetry device using this electrode was then studied for its accuracy in measuring manganese present in the voids of river sediments. We examined the correlation of the electrode current with Mn2+ concentration through calibration. For this purpose, we analysed currents 3 times per each concentration ranging from 0.1 to 0.4 mM at 0.1 increment. As a result, coefficient of determination was found to be 0.98, suggesting good correlation. Developed microelectrode looks promising to be used for reliable voltammetry of Mn^{2+} concentration.

Life Cycle Assessment for Environmental Impact of Biochar Produced in Different Temperature

JiYeong Boo, JyungHo Park, Yong Sik Ok, Yongseok Hong*

Korea University, Republic of Korea

This study presents a comprehensive life cycle evaluation of manufacturing biochar by varying the pyrolysis temperature. Biochar, a carbonaceous material produced through the thermal decomposition of biomass, has gained attention as a promising substance for carbon sequestration and soil conditioner. The study conducted in this study focuses on analyzing the life cycle environmental impacts of biochar manufacturing at different pyrolysis temperatures. Using open. LCA software, we comprehensively evaluate the environmental impact of biochar manufactured by pyrolysis at 300˚C, 400˚C, and 500˚C in consideration of system boundaries and process flow of biochar manufacturing process. Systematic evaluations are carried out, considering key factors such as energy consumption, greenhouse gas emissions, resource depletion, and other relevant environmental indicators. The results of this research provide valuable insights into the environmental impacts of temperature-dependent biochar manufacturing. By considering the life cycle perspective, we can make decisions about environmentally good pyrolysis conditions for bio-tea production, and balance environmental issues with resource efficiency.

Algae Cultivation for Feedstock of Bioplastics Production and Wastewater Bioremediation for Palm Oil Industry

Wai Yan Cheah

Universiti Kebangsaan Malaysia, Malaysia

The manufacturing rate of disposable plastic products is currently overwhelming the world's capability to deal with them. Plastics and microplastics pollution has presently becoming the major environmental challenge to the human race and environment. The recycling of plastic waste rate is considerably low, especially in many developing countries. To overcome this environmental issue, the production of non-degradable conventional plastics adopted by petroleum-based sources should be reduced and to be substituted with bioplastics. Further, crude palm oil producing countries, especially Malaysia and Indonesia, is generating massive amount of palm oil mill effluent (POME) at daily basis. POME generated during the milling process exhibits high loads of organics, and therefore is posing risk to receiving water bodies. To resolve and mitigate both mentioned environmental issues, the potential of algae-based bioplastics production and POME bioremediation, could be investigated for its future perspectives. Conventional feedstock for bioplastics production are the edible crops which have been available for decades. Aside from these feedstocks, photosynthetic algae have shown remarkable potential in generating productive biomass while cultivating in POME, performing carbon fixation abilities in producing sugars for bacterial fermentation and subsequently used for the bioplastics production. Algae biomass could as well be blended with synthetic polymers or bioplastics due to its high polysaccharides composition. Moreover, some algal species are found promising in accumulating high amounts of polyhydroxyalkanotes (PHA) and polyhydroxybutyrate (PHB) within their cells. Therefore, the present study is comprehensively discussing on the potential of waste valorisation in palm oil industry to achieve both algae-based bioplastics production and POME bioremediation. This study is foreseen to bring new insights to industrial stakeholders, researchers, business entities and the Government in decision making in their field. This works towards overall environmental sustainability and well-being of the society.

Biodegradable Poly(butylene Adipate-co-terephthalate) and Poly(lactic Acid) Plastics: Degradation and Their Effects on Soil Properties

Pavani Dulanja Dissanayake[1,2#], Piumi Amasha Withana[1#], Mee Kyung Sang[3], Yoora Cho[1], Jeyoung Park[4,5], Dongyeop X. Oh[4], Scott X. Chang[6], Carol Sze Ki Lin[7], Michael S. Bank[8,9], Sung Yeon Hwang[4,10]**, Yong Sik Ok[1,11]*

[1]*Korea University, Republic of Korea*
[2]*Coconut Research Institute, Sri Lanka*
[3]*National Institute of Agricultural Sciences, Republic of Korea*
[4]*Korea Research Institute of Chemical Technology (KRICT), Republic of Korea*
[5]*Sogang University, Republic of Korea*
[6]*University of Alberta, Edmonton, Canada*
[7]*City University of Hong Kong, China*
[8]*Institute of Marine Research, Bergen, Norway*
[9]*University of Massachusetts Amherst, US*
[10]*Kyung Hee University, Republic of Korea*
[11]*The University of Queensland, Australia*

Continue on next page

Biodegradable Poly(butylene Adipate-co-terephthalate) and Poly(lactic Acid) Plastics: Degradation and Their Effects on Soil Properties

The fate of biodegradable plastics in the environment is poorly understood. Existing Environmental, Social, and Governance (ESG) frameworks and new regulations imposed by the UNEP to end plastic pollution require evidence of plastic degradation in soils. Here, we studied the degradation rate of two biodegradable plastics, poly(butylene adipate-co-terephthalate) (PBAT) and poly(lactic acid) (PLA), in a 33-week laboratory microcosm experiment, with natural soils containing 8.3% (w/w) PBAT or PLA. We determined CO_2 efflux and changes in the chemical and microbiological properties of the soils. Both PBAT and PLA treatments increased cumulative CO_2 efflux compared to the control soil when incubated at 25 and 58 ˚C. After 33 weeks, 8.05 and 6.20% of PBAT and PLA, respectively, were degraded at 58 ˚C, whereas 2.2 and 1.6 %, respectively, were degraded at 25 ˚C. Their degradation at 58 ˚C increased both total soil carbon (0.58, 1.93, and 4.38% for the Control, PBAT and PLA, respectively) and soil EC (0.17, 0.33, and 2.38 dS m-1, respectively) but decreased the pH (7.92, 6.31, and 3.65%, respectively). The microbial diversity and richness in soils were also reduced due to thermophilic conditions at 58 than 25 ˚C. These findings indicate that PBAT and PLA can break down under various soil conditions, and their degradation will alter the soil properties.

# These authors contributed equally.

NIR-Triggered High-Efficiency Self-Healable Protective Optical Coating for Vision Systems

Ji-Eun Jeong[1], Jae-Won Lee[2], Mi Ju Bae[1], Hyoung Eun Bae[1], Eunjeong Seo[1], Seulchan Lee[1], JungYeop Shin[2], Sang-Ho Lee[1], Yu Jin Jung[1], Hyocheol Jung[1], Young Il Park[1*], In Woo Cheong[2*], Hak-Rin Kim[2*], and Jin Chul Kim[1*],

[1]Korea Research Institute of Chemical Technology, Republic of Korea
[2]Kyungpook National University, Republic of Korea

Recently, self-healing materials have evolved to recover specific functions such as electronic, magnetic, acoustic, structural or hierarchical, and biological properties. In particular, the development of self-healing protection coatings that can be applied to lens components in vision systems such as augmented reality glasses, actuators, and image and time-of-flight sensors has received intensive attention from the industry. In the present study, we designed polythiourethane dynamic networks containing a photothermal N-butylsubstituted diimmonium borate dye to demonstrate their potential applications in self-healing protection coatings for the optical components of vision systems. The optimized self-healing coating exhibited a high transmittance (~95% in the visible-light region), tunable refractive index (up to 1.6), a moderate Abbe number (~35), and high surface hardness (>200 MPa). When subjected to near-infrared (NIR) radiation (1064 nm), the surface temperature of the coating increased to 75 ˚C via the photothermal effect and self-healing of the scratched coatings occurred via a dynamic thiourethane exchange reaction. The coating was applied to a lens protector, and its self-healing performance was demonstrated. The light signal distorted by the scratched surface of the coating was perfectly restored after NIR-induced self-healing. The photoinduced self-healing process can also autonomously occur under sunlight with low energy consumption.

Design of Topology-Controlled Polyethers Toward Robust Cooperative Hydrogen Bonding

Junhee Kim[1,2], Soonyoung Choi[1], Jinsu Baek[3], Yong il Park[1], Jin cheol Kim[1], Ji-Eun Jeong[1], Hyocheol Jung[1], Tae-Hyuk Kwon[2*], Byeong-Su Kim[3*],Sang-Ho Lee[1*]

[1]Korea Research Institute of Chemical Technology, Republic of Korea
[2]Ulsan National Institute of Science and Technology (UNIST), Republic of Korea
[3]Yonsei University, Republic of Korea

As a function of important molecular parameters, controlling the polymer topologies is critical to determine the physical properties and applications. Particularly, the polymer topologies, carrying numerous hydrogen bonding (H-bonding) donor and acceptor in polymer chains, strongly influence their unique properties by inducing the different inter- and intramolecular H-bonding. Herein, we present the investigation of a high-level control of the inter- and intramolecular H-bonding in the topology-controlled poly(glycidoxy carbonyl benzoic acid)s (PGCs) (i.e., linear, hyperbranched, and branched cyclic structures having a similar degree of polymerization). The topology-controlled PGCs were successfully prepared by introducing the aromatic carboxylic acids in the corresponding polyglycidols (PGs) via quantitative post-polymerization modification using phthalic anhydride and organic base as a nucleophilic catalyst. The resulting polymers were analyzed by 1H NMR, SEC, and TGA. The obtained three types of PGCs were demonstrated the high-level interplay between the inter- and intramolecular H-bonding in polymer chains by exhibiting the pH-dependent self-association properties in the solution state and the strong adhesion properties in the bulk state with high transparency. Interestingly, the dramatically enhanced adhesive property by 2.6-fold was demonstrated by simple mixing of branched cyclic PGC and topology-controlled PGs to promote the cooperative H-bonding between polymer chains. We anticipate the new class of cooperative H-bonding between topology-controlled polymers contribute to the development of advanced adhesive and the high potential in biological and biomedical applications due to its excellent biocompatibility.

Fast, Localized, and Low-Energy Consumption Self-Healing of Automotive Clearcoats Using a Photothermal Effect Triggered by NIR Radiation

Da Hae Son[1], Hyoung Eun Bae[1], Mi Ju Bae[1], Sang-Ho Lee[1], In Woo Cheong[2,*], Young Il Park[1*], Ji-Eun Jeong[1*], Jin Chul Kim[1*]

[1]*Korea Research Institute of Chemical Technology, Republic of Korea*
[2]*Kyungpook National University, Republic of Korea*

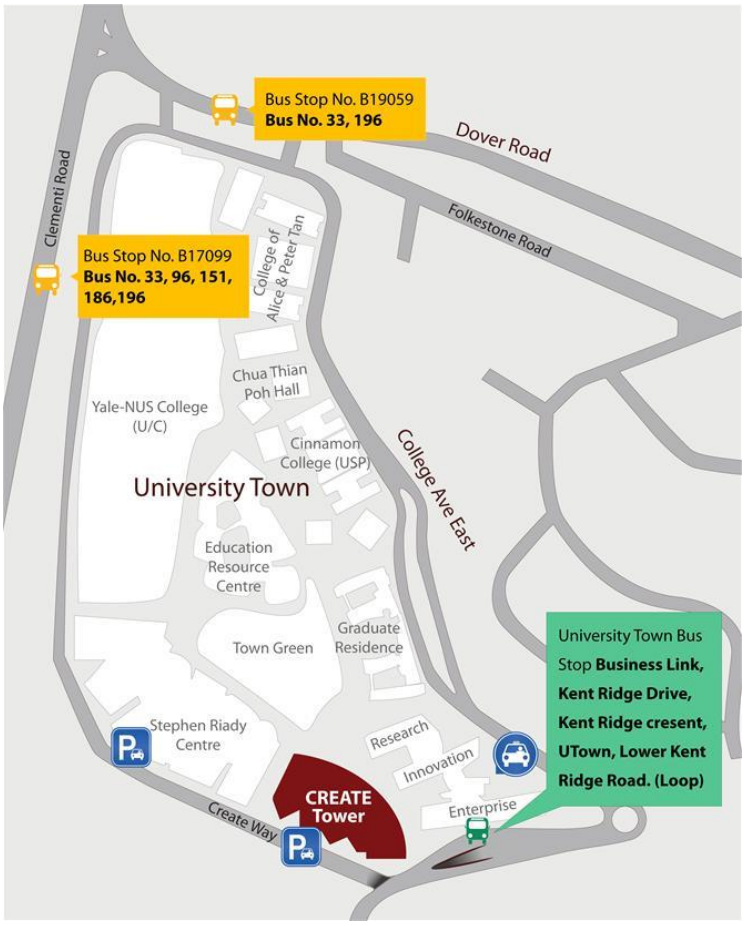
Dynamic polymer networks containing photothermal materials have been reported to demonstrate highly efficient intrinsic self-healing under irradiation. In particular, organic near-infrared-absorbing ionic salts, such as diimmonium dyes, function as transparent polymer heaters and can enhance the self-healing properties of clearcoats. In this study, we designed a self-healing automotive clearcoat with a reversible polymer network based on acryl polyol (AP) and dynamic hindered urea (HU) bonds and introduced N-butyl-substituted diimmonium borate dye (DID) as a photothermal dye. To optimize the selfhealing efficiency of the clearcoat and its transparency in the visible light region, the effects of the presence or absence of dynamic HU bonds and the concentration of the photothermal dye were precisely investigated. For a polymer system containing HU with 0.1 wt% DID (AP/HU-DID_0.1), the transparent automotive clearcoat was heated to ~70 °C under focused sunlight irradiation and exhibited excellent (~100% healing efficiency) and fast (<30 s) scratch-healing performance compared with a commercial automotive clearcoat. In addition, this photothermal effect-based self-healing clearcoat exhibited outstanding transparency (over 95%) and has a strong advantage with respect to energy consumption because it enables faster and more localized healing compared with thermal healing processes that require heating the entire product.

CREATE Tower

Directions to CREATE Tower

The following are road directions to the NRF Singapore Headquarters via the following modes of transport:

- Public transport (bus and train)
- Cars and other vehicles – via the Ayer Rajah Expressway (AYE)
- Cars and other vehicles – via Dover Road



Directions to CREATE Tower by MRT

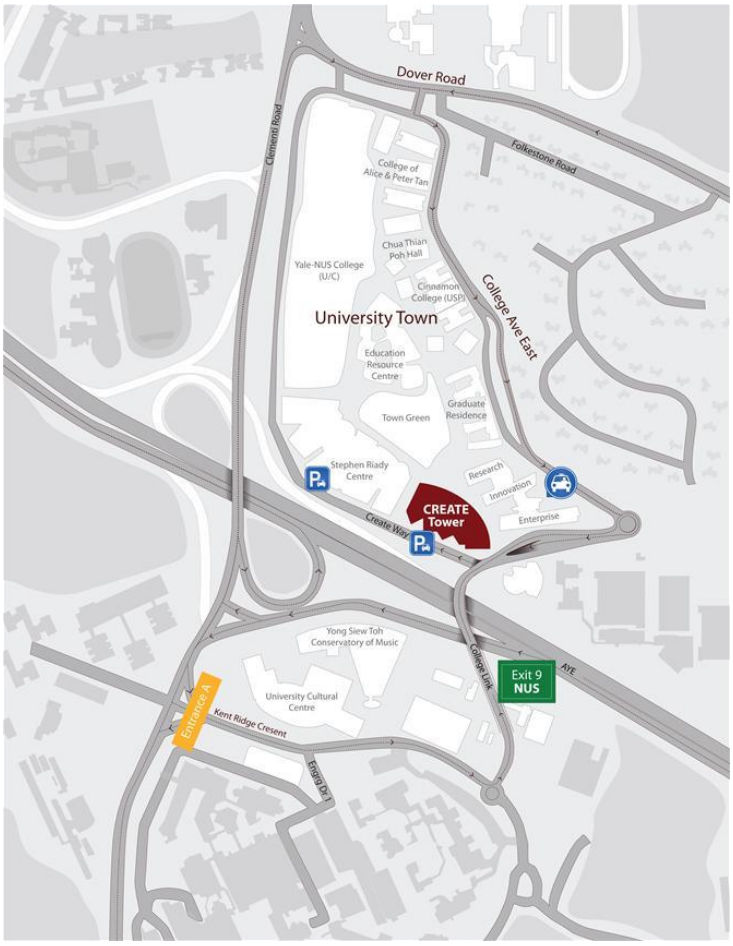
1.Alight at Kent Ridge MRT Station (CC24, Circle Line) and proceed to Lower Kent Ridge Road Exit

2.Proceed to Bus Stop No. 18221 (right after NUH entrance)

3.Take bus service “D2” to University Town. Alight at University Town Bus Stop

CREATE Tower

Directions to CREATE Tower



Directions to CREATE Tower via AYE (towards Tuas)

1.Along AYE towards Tuas, exit at Exit 9

2.Turn left on Clementi Road

3.Turn left onto Kent Ridge Crescent (Landmark: University Cultural Centre on left)

4.Turn left onto College Link at roundabout

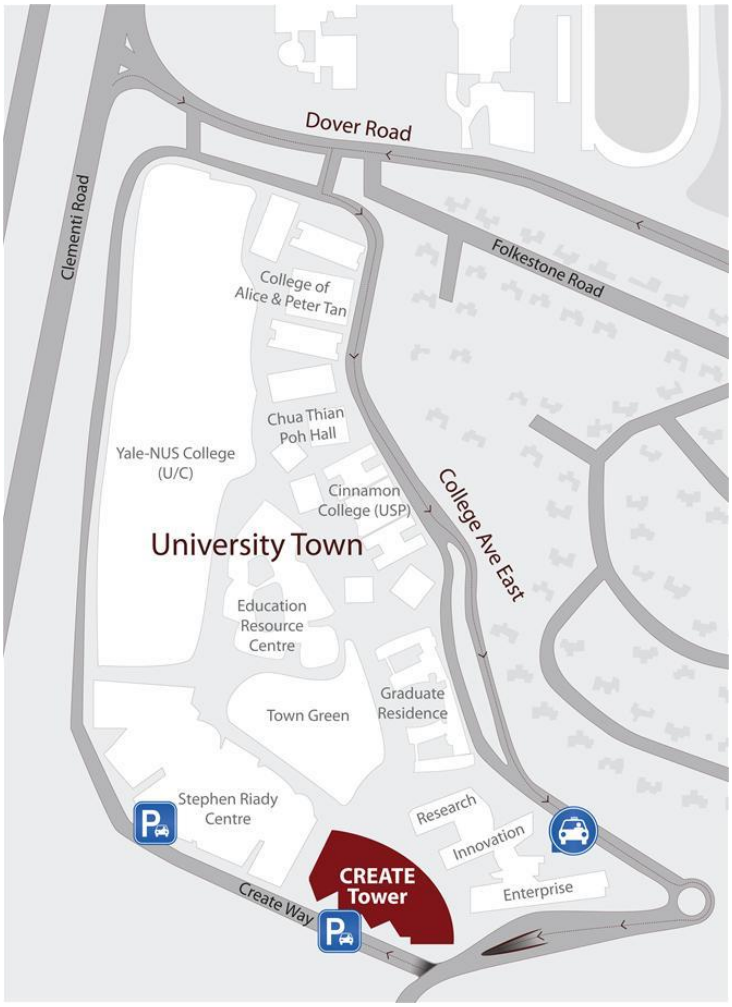
5.Proceed straight along Create Way

6.At roundabout, turn right and proceed down road ramp

7.Proceed to CREATE Tower carpark, turn right

CREATE Tower

Directions to CREATE Tower



Directions to CREATE Tower via Dover Road

1.Head onto Dover Road from Clementi Road

2.Turn right into University Town (Turn left if you are coming from North Buona Vista Road onto Dover Road)

3.Keep left and continue onto College Avenue East

4.Turn right after the roundabout onto Create Way

5.Proceed down the road ramp

6.Proceed to CREATE Tower carpark, turn right

Accommodation

Park Avenue Rochester (SG Clean)

Experience the epitome of relaxation at Park Avenue Rochester, situated amidst the serene greenery of Rochester Park and adjacent to Rochester Mall. This contemporary establishment boasts modern rooms and suites equipped with complimentary WiFi, along with an inviting outdoor swimming pool. Within a short 2-minute drive, an array of dining and shopping options await in Holland Village, while the convenience of Buona Vista MRT Train Station is a mere 7-minute stroll from the property. Nearby attractions such as Orchard Road, Vivo City, and Sentosa can be reached within a convenient 15-minute drive. The air-conditioned accommodations feature expansive windows, bathing the rooms in natural light. Standard amenities include a flat-screen TV, electric kettle, and private bathrooms with hairdryers, bathtubs, and/or showers. Health-conscious guests will appreciate the fitness center, and the hotel offers a 24-hour reception with express check-out services. Babysitting services are also available for added convenience. Indulge in delectable California cuisine and savor a continental breakfast at the on-site restaurant, providing an exquisite culinary experience to enhance your stay.

Accommodation

Park Avenue Rochester Shuttle Bus Schedule

	27th June	28th June	29th June
Park Avenue Rochester → CREATE Tower	08:45	09:15	09:15
CREATE Tower → Park Avenue Rochester	18:00	18:00	15:30

Accommodation

The Ritz-Carlton, Millenia Singapore

Nestled in the heart of Marina Bay, The Ritz-Carlton, Millenia Singapore offers an exquisite retreat where guests are enveloped by sheer elegance. This prestigious hotel showcases opulent accommodations, boasting a curated collection of over 4,200 exquisite art pieces. The Club Lounge presents a refined haven, granting panoramic vistas of Singapore's awe-inspiring skyline. Indulgence takes center stage with exceptional dining experiences, including Michelin-starred Cantonese cuisine at Summer Pavilion, a delightful array of culinary Asian delicacies at Colony, and rejuvenating treatments at The Ritz-Carlton Spa, recognized as one of the pioneering La Mer hotel partner spas in the Asia Pacific region.

Accommodation

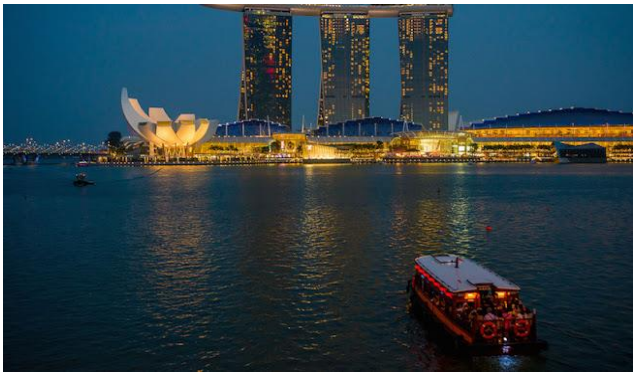
Marina Bay Sands, Singapore

Live the high life in the breathtaking world of Marina Bay Sands. This is where you can touch, feel, and imagine. Extraordinary luxury awaits your stay at Marina Bay Sands. From restorative spa treatments to swims in the world's largest infinity pool, expect nothing less than indulgent experiences with our first-class amenities.

Enjoy Singapore

Top 10 Tour Spots of Singapore

01. Marina Bay Sands



If construction costs are a topic of interest, then one would be enthralled by the awe-inspiring Marina Bay Sands. This remarkable resort, with a staggering price tag of US$5.7 billion during its construction, holds the distinction of being the world's most expensive building upon its grand opening in 2010. Offering a comprehensive experience, the Marina Bay Sands encompasses a luxurious hotel, a diverse array of dining options, an extensive collection of shops, an expansive convention center ranking among Asia's largest, a theater, an ArtScience Museum, and various entertainment centers. Moreover, it boasts an exceptional indoor skating rink crafted with synthetic ice, further elevating its allure.

02. Singapore Flyer

Offering far more than breathtaking views, the Singapore Flyer stands as a colossal Ferris wheel that redefines the notion of grandeur. Enveloped in awe-inspiring vistas, its spacious capsules gracefully transport up to 28 individuals on a captivating journey above the cityscape. Since its inauguration in 2008, this iconic landmark has held the esteemed title of the world's tallest Ferris wheel, soaring an impressive 165 meters (541 feet) into the captivating Singaporean sky. Notably, with prior arrangements, the Flyer warmly accommodates disabled guests in wheelchairs, ensuring inclusivity for all. Situated on Marina Bay, the Flyer's terminal offers a multi-dimensional experience with its three floors housing an enticing selection of restaurants, shops, and various services.

Enjoy Singapore

Top 10 Tour Spots of Singapore

03. Buddha Tooth Relic Temple

Among the myriad temples constructed by the Chinese, the Buddha Tooth Relic Temple stands out as a distinctive marvel. Originally intended to be a conventional Buddhist temple when proposed in Singapore's Chinatown during the late 1980s, it took a fascinating turn to become the revered abode of a tooth relic from Buddha. Situated in the heart of central Chinatown, this temple not only houses the sacred relic but also showcases the rich tapestry of arts and culture belonging to the Singaporean Buddhist community.

04. Night Safari

The Night Safari in Singapore stands as the world's pioneering nocturnal zoo, situated in Mandai, Singapore. Renowned as one of the country's premier tourist attractions, it forms an integral part of the Mandai Wildlife Reserve, which encompasses the River Wonders, Singapore Zoo, and Bird Paradise. Conceived in the 1980s under the visionary leadership of Dr. Ong Swee Law, the former executive chairman of the Singapore Zoo, the idea of establishing a nocturnal park took shape. With a construction cost of S$63 million, the Night Safari was officially inaugurated on 26 May 1994. Spanning across 35 hectares (86 acres) of lush secondary rainforest, it resides adjacent to the Singapore Zoo and Upper Seletar Reservoir, creating an enchanting and immersive experience for visitors.

Enjoy Singapore

Top 10 Tour Spots of Singapore

05. Singapore Botanic Gardens

Discerning travelers seeking value-conscious experiences will find solace in the Singapore Botanic Gardens, where the majority of the gardens can be explored free of charge. Only the National Orchid Garden, which stands as the garden's most frequented section, incurs an admission fee. Spanning a vast expanse, this botanical paradise boasts an impressive array of over 60,000 species of plants and animals, while also proudly hosting the world's pioneering children's garden. Past visitors effusively praise the lush tropical greenery that envelops the gardens, ensuring an enchanting experience for all who venture within its captivating confines.

06. Gardens by the Bay

Gardens by the Bay, a noteworthy addition to Singapore's array of tourist attractions, presents an indispensable destination for gardening enthusiasts. Developed on reclaimed land in central Singapore, this remarkable site has emerged as a triumvirate of gardens: Bay Central, featuring a scenic waterfront promenade that will eventually link the other two gardens; Bay East, gradually unveiling its splendors as sections reach completion; and Bay South, the largest garden renowned for its tropical horticulture and commanding tree-like structures that soar up to 50 meters (160 feet) in height, dominating the landscape of the Gardens with their majestic presence. Since its inception less than a decade ago, Gardens by the Bay has swiftly become an essential stopover for those seeking to immerse themselves in the artistry of nature.

Enjoy Singapore

Top 10 Tour Spots of Singapore

07. Raffles Hotel

Exemplifying Singapore's timeless allure, Raffles Hotel stands as an iconic embodiment of colonial elegance. Since its establishment in 1887, it swiftly ascended to the pinnacle of prestigious accommodations, attracting luminaries such as Rudyard Kipling, Somerset Maugham, and Ernest Hemingway, who contributed to its illustrious reputation. This epitome of opulence boasts a remarkable selection of 15 restaurants and bars, including the renowned Long Bar where the iconic Singapore Sling cocktail was first concocted. Raffles Hotel's global renown extends to its meticulously attired Sikh doormen, who warmly welcome guests into this cherished bastion of Southeast Asian history. While the main building's lobby graciously opens its doors to the public, the hotel museum, a hidden gem, resides discreetly on the third floor, offering a captivating glimpse into its storied past.

08. Clarke Quay

Clarke Quay, a testament to Singapore's rich historical tapestry, remains a vibrant and thriving locale to this day. Once the bustling epicenter of commerce in the late 19th century, this riverside quay, located at the mouth of the Singapore River, has evolved into a captivating tourist destination. Seamlessly fusing Asian and European influences, Clarke Quay exudes an alluring energy, bustling with trendy restaurants, distinctive boutiques, lively pushcart vendors, and more. By nightfall, the scene undergoes a transformation, as chic nightspots come alive, further enhancing the vibrant ambiance of this cherished marketplace that continues to hold its allure throughout the passage of time.

Enjoy Singapore

Top 10 Tour Spots of Singapore

09. Resort World Sentosa

Resorts World Sentosa stands as a captivating and comprehensive destination in Singapore, located on an island just off the southern coast. Boasting a diverse array of hotels, restaurants, a casino, and theme parks, this extraordinary property offers something for visitors of all ages. Positioned amidst a coastal backdrop, the attractions revolve around the sea, featuring the Marine Life Park, Dolphin Island, a thrilling water park, and an enchanting aquarium. Additionally, guests can indulge in the excitement of Universal Studios Singapore and enjoy nightly entertainment offerings. The casino presents an extensive selection of table games and 2,400 slot machines, albeit with a dress code requirement. To satiate culinary cravings, the resort proudly showcases over 60 dining options, ensuring a delightful experience for all discerning guests.

10. Orchard Road

Orchard Road, Singapore's premier shopping destination, garners consistent patronage from both local residents and international tourists. Derived from its historical connection to fruit orchards, Orchard Road is renowned for its impressive array of upscale malls, fine dining establishments, popular coffee chains, inviting cafés, vibrant nightclubs, and luxurious hotels. Notably, it is also home to the distinguished Istana, serving as the official residence of the President of Singapore. During the Christmas season, Orchard Road dazzles with its renowned extravagant decorations, where palm trees intertwine with playful reindeers, and gingerbread houses adorned with faux snow, creating a whimsical spectacle for all to behold.

Committees

ESG Overview

Jay Hyuk Rhee(Chair)

President, International ESG Association, Republic of Korea
Professor, School of Business Administration,
Korea University, Republic of Korea
Director, Korea University ESG Research Institute, Republic of Korea

Won Seog Park

Professor, School of Law, Chung-Ang University,
Republic of Korea

Yongjun Sung

Professor, School of Psychology, Korea University,
Republic of Korea
President, Korea Society for Consumer and Advertising Psychology,
Republic of Korea

Shauhrat S. Chopra

Professor, School of Energy and Environment,
City University of Hong Kong, China

Voluntary Carbon Market-Carbon Negative & Biochar

Kua Harn Wei(Chair)

Professor, Department of the Built Environment,
College of Design and Engineering,
National University of Singapore, Singapore

Chi-Hwa Wang

Professor, Department of Chemical and Biomolecular Engineering,
College of Design and Engineering,
National University of Singapore, Singapore

Daniel C.W. Tsang

Professor, Department of Civil and Environmental Engineering,
The Hong Kong Polytechnic University, China
Pao Yue-Kong Chair Professor, Zhejiang University, China
2022 Highly Cited Researcher
(Environment and Ecology and Engineering)

Su Shiung Lam

Professor, Higher Institution Centre of Excellence (HICoE),
Institute of Tropical Aquaculture and Fisheries (AKUATROP),
University of Malaysia Terengganu, Malaysia

Voluntary Carbon Market-Carbon Negative & Biochar

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Korea University Sejong Campus, Republic of Korea

Ioannis Manariotis

Professor, Department of Civil Engineering,
University of Patras, Greece

Elsa Antunes

Professor, College of Science & Engineering,
James Cook University, Australia

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University Malaya, Malaysia

Hwai Chyuan Ong

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National Yunlin University of Science and Technology, Taiwan

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Chuanfang Fan

Ph.D. Scholar, College of Resources and Environment, University of Chinese Academy of Sciences, China

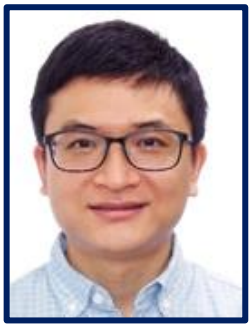
Seong Ku Kwon

Masters & Ph.D. Scholar, Division of Environmental Science and Ecological Engineering, Korea University, Republic of Korea

Sustainable Plastic Management

Sung Yeon Hwang(Chair)

Professor, Department of Plant & Environmental New Resources,
Kyung Hee University, Republic of Korea



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University of Glasgow, UK

Fang Wang

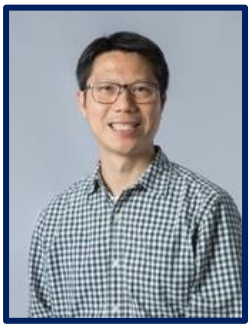
Professor, Institute of Soil Science,
Chinese Academy of Sciences, China

Eakalak Khan

Professor, Civil and Environmental Engineering and Construction,
University of Nevada, US

Patryk Oleszczuk

Professor, Department of Radiochemistry and Environmental Chemistry, Institute of Chemical Sciences, Faculty of Chemistry, Maria Curie-Sklodowska University, Poland



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Professor, Laboratory of Toxicology Applied to the Environment, Goiano Federal Institute, Urutaí, GO, Brazil

Muchlisin Zainal Abidin

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Syiah Kuala University, Indonesia

Cheah Wai Yan

Professor, Centre for Research in Development,
Social and Environment (SEEDS) Faculty of Social Sciences and
Humanities, University Kebangsaan Malaysia, Malaysia

Qianru Zhang

Professor, Institute of Agricultural Resources and Regional Planning,
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Xiangzhou Yuan

Professor, Ministry of Education of Key Laboratory of Energy Thermal Conversion and Control,
School of Energy and Environment, Southeast University, China

Amasha Withana

Ph.D. Scholar, Division of Environmental Science and Ecological Engineering, Korea University, Republic of Korea

Suho Han

Ph.D. Scholar, Division of Environmental Science and Ecological Engineering, Korea University, Republic of Korea

HYUNDAI MOTORS ON TRACK FOR CARBON NEUTRAL GOAL

HYDROGEN AND BATTERIES are both in the sustainability mix for South Korean automobile manufacturer's ESG-led strategy.

Hyundai Motor Company has been commended by the International ESG Association (IESGA) for its sustainability performance and climate change strategy, which will see the company become carbon neutral by 2045 across all stages, including parts procurement, production, and vehicle operation.

"IESGA worked with Korea University's ESG Research Center to identify the best-performing global company in Korea, and our screening process found that Hyundai Motors operated better than the other competitors," says co-presidents of the IESGA, Jay Hyuk Rhee and Yong Sik Ok, who are also full professors at Korea University in Seoul, South Korea.

Rhee and Ok say the assessment was based on IESGA's comprehensive analysis of Hyundai's environmental, social, and governance (ESG) performance, direction, and future agenda.

Founded in 1967, Hyundai now operates the world's single largest automotive manufacturing plant, located in Ulsan. In March 2022, Hyundai Motor Group launched a new sustainability vision: 'The Right Move for the Right Future', outlining 15 focus areas, in three categories: 'planet', which covers environment and circular economy strategies; 'people', which includes safety, diversity and growth; and 'community', which addresses the company's impact on customers and suppliers.

This commitment has international significance, because of Hyundai's huge global reach, Rhee says. Hyundai Motor Group's executive chair, Chung Eui-sun, met US President Joe Biden in May 2022 after committing $5.5 billion to establish an electric vehicle (EV) assembly and battery plant in Georgia, which will help accelerate renewable energy adoption in the US, the world's second-largest automobile market after China.

NEUTRALITY PROMOTES EVS

Hyundai's goal to achieve carbon neutrality by 2045 will promote advanced environmental technologies already underway for electric vehicles, fuel cell electric vehicles, and hydrogen energy.

In line with the global corporate renewable energy initiative 'RE100' target, Hyundai Motor Company, Kia Corporation, Hyundai Mobis and Hyundai Wia are scheduled to transition to 100% renewable energy by 2050, with green hydrogen to play a big part in major manufacturing procedures.

"Our company is developing both battery-powered electric vehicles and hydrogen-powered electric vehicles, including passenger cars and commercial vehicles," says Byung Hoon Lee, vice president of Hyundai Motor Company. "It has formed important partnerships with SK and with LG Energy Solutions, the world's largest electric vehicle battery manufacturer," Ok says.

Currently, more than 90% of the world's hydrogen production is manufactured using fossil fuels, but Hyundai will cooperate with carbon neutral hydrogen suppliers.

The company also plans to expand hydrogen-powered mobility to ships, trains and hydrogen-electric powered AAM (Advanced Air Mobility) systems such as personal air vehicles over the longer term.

▲ **Electric vehicles are a key part of Hyundai Motor Company's plan to achieve carbon neutrality by 2045.**

FULL CIRCLE

Hyundai already has robust water recycling practices in countries with severe shortages, with manufacturing plants in India, for example, recycling 100% of water through a zero-liquid-discharge system.

In 2018, Hyundai Motors Brazil introduced a zero-landfill campaign and now recycles 98% of waste including paint, thinner and packaging, with the remaining 2% composted.

Hyundai has also established what it calls 'second life' EV-battery-based, energy-storage-system businesses that will reuse recovered batteries with 70% remaining capacity, and auto parts recovered from cars at the end of their driving life. ■

HYUNDAI

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LG ELECTRONICS POSITIONS ITSELF AS ESG MARKET LEADER

LG Electronics demonstrates how Environmental, Social, and Governance considerations can be WOVEN INTO A COMPANY'S BUSINESS PRACTICES and operations.

Environmental, Social, and Governance (ESG) considerations play increasingly crucial roles in a company's prospects and viability.

Key stakeholders, including consumers and investors, regulators, and non-government organizations, are demanding that companies incorporate ESG factors into nearly every aspect of their business strategy and operations, from procurement and manufacturing through to product development and hiring.

South Korea's LG Electronics (LGE), a global leader in information technology with about 30 production sites worldwide, has recognized that for ESG management to be effective it needs to be integrated into a company's day-to-day operations.

▲ **LG Smart Park at Changwon, South Korea.**

"Changes in the social perception of the impact of companies have led to the emergence of ESG management," says Jay hyuk Rhee, professor in the School of Business Administration at Korea University and chair of LG's ESG advisory committee.

These changes, he says, reflect "a need to improve corporate sustainability by comprehensively examining business activities based on ESG principles."

TOWARDS A BETTER LIFE

In 2018, LGE outlined its strategic direction for its ESG management based on standards required by the international community, which reflected the Sustainable Development Goals established by the United Nations.

Following a review of its ESG performance over the previous three years, the company established a new direction for its ESG programme and, in 2022, launched *The Better Life Plan 2030*.

The plan reflects current global ESG trends, and includes a new ESG vision and strategy to be overseen by an advisory committee. "Implementing an ESG program can be very challenging for companies," says Yong Sik Ok, professor and programme director in the Associations of Pacific Rim Universities (APRU) Sustainable Waste Management Program at Korea University in Seoul, and a member of the LG's ESG advisory committee.

"Not only are the E, S, and G highly interrelated, but it is also practically impossible to identify all the individual issues that fall under each category," he says.

"LGE aims to promote

ESG management across the business, and ensure that sustainability is embedded within the company's operations and processes," says Sung-min Hong, head of the company's ESG department.

The Better Life Plan 2030 includes six ESG commitments, three of which aim to significantly improve the company's environmental performance by reducing its greenhouse gas (GHG) emissions and increasing the use of recycled materials in its products.

For example, LGE has committed to becoming carbon-neutral by 2030 by reducing emissions generated from its production processes.

To achieve this, the company plans to reduce by 50% the 1.93 million tonnes of carbon dioxide equivalent (tCO_2e) generated in 2017 by creating more energy-efficient facilities and adopting emission reduction technologies.

To support its carbon-neutrality goal, the company has transformed its factory complex, in Changwon, South Korea, into a futuristic manufacturing hub for its home appliances line.

Renamed the LG Smart Park, the complex uses a digitally enabled 3D logistics system, advanced edge computing and machine learning analytics to predict defects, and state-of-the-art facilities to produce multiple models that respond to customer requirements.

Earlier this year, the World Economic Forum selected the complex as a Lighthouse Factory — these showcase companies that demonstrate leadership in using Fourth Industrial Revolution technologies.

According to LGE, the LG Smart Park has increased productivity by 17% and reduced the cost of defective-product returns by 70%. The factory has reduced GHG emissions and boosted energy efficiency per unit produced by 30% compared to an earlier site.

LGE plans to apply the smart production technologies pioneered at LG Smart Park to 26 of its production facilities in 13 countries, accelerating the digital transformation of its global manufacturing network by 2025.

The remaining 960,000 tCO_2e generated in 2017, says the company, will be offset by securing carbon credits through the United Nations Framework Convention on Climate Change's Clean Development Mechanism, which allows it to reduce emissions by investing in technology and capital in developing countries, and through external carbon reduction activities by utilizing its high-efficiency home appliances.

Under the ESG framework, LGE aims to source 60% of its energy from renewable technologies by 2030, transitioning to 100% renewable by 2050.

POWERING THE CIRCULAR ECONOMY

LGE is also committed to building a circular economy through waste recycling initiatives and improving waste treatment processes, and aims to recycle 95% of waste generated at its global production sites by 2030, up from 92% in 2021, by utilizing 600,000 tonnes of recycled plastics in its manufacturing processes.

"Conducting product stability and quality reliability tests will improve resource efficiency, with recycled materials being used in a range of products, from washing machines and refrigerators to air conditioners and TVs," says Hong. "LGE is also implementing policies to comply with regional regulations on the take-back and disposal of e-waste by establishing infrastructure for the recovery of e-waste.

▲ **LG Electronics is committed to building a circular economy, including the recovery of e-waste.**

VLADIMIR BULBAR/SCIENCE PHOTO LIBRARY/Getty

This approach reflects the European Communities' directive on Waste Electrical and Electronic Equipment, which requires countries to achieve a cumulative e-waste recovery rate of 8 million tonnes by 2030, says Hong. To support its efforts the company opened the Chilseo Recycling Center, in South Korea, in August 2001.

"The facility is spearheading the company's e-waste initiative by collecting electronic waste at the end of product lifecycles and re-using recycled plastic to manufacture new components for use in home appliances like refrigerators," he explains.

LGE is also improving the energy performance of its products. For example, In June, the company launched its new ThinQ washing machine, which features an Artificial Intelligent Direct Drive (AI DD) motor. The motor uses deep learning to identify different types of fabrics and then selects the optimal cycle and settings for each load.

In a first for the home appliance industry, the ThinQ received the AI Algorithm Reproducibility Process Verification from UL, a global safety science leader, which helps companies to demonstrate safety, enhance sustainability, and achieve regulatory compliance.

"LGE's current activities are in line with our mid- to long-term ESG strategy to produce eco-friendly products and services for future generations," says William Cho, CEO of LG Electronics. "LGE is actively working on environmental solutions, so that future generations can enjoy a better life and contribute to a better tomorrow." ■

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