icRS 2024

2024 International Conference on Resource Sustainability

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Thammasat University

Rajamangala University of Technology Rattanakosin

2024 International Conference on Resource Sustainability

(icRS 2024)

Welcome to icRS 2024!

The sustainable development of human society depends on resources. Addressing critical societal challenges, such as climate change, resource depletion, and environmental protection, requires sustainable management of resources using interdisciplinary approaches.

The **International Conference on Resource Sustainability (icRS)** series serve as an international platform for researchers and practitioners around the world with diverse background and expertise to share the most recent ideas, outcomes, and practices on resource sustainability.

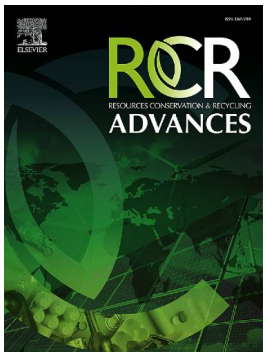
icRS embraces interdisciplinarity, welcoming contributions from ANY discipline including natural sciences, social sciences, and engineering on ANY aspect of resource sustainability. We define resource broadly, including physical resources, biological resources, and "misplaced" resources:

- physical resources: metals, non-metallic minerals, energy, water, etc.
- biological resources: food, forestry, land, ecological systems, etc.
- "misplaced" resources: air emissions, water pollutants, solid waste, etc.

icRS 2024, co-hosted by ***Thammasat University*** and ***Rajamangala University of Technology Rattanakosin***, will include invited keynote speeches, parallel sessions, and poster presentations on a variety of topics related to resource sustainability.

icRS 2024 is sponsored by the flagship journal in sustainable resources management ***Resources, Conservation & Recycling*** (RCR; 2023 Impact Factor: 11.2) and its sister journal ***Resources, Conservation & Recycling Advances*** (RCRADV; 2023 Impact Factor: 5.4). High quality papers presented at icRS 2024 will be recommended to special issues in these journals as well as other supporting journals.

We are looking forward to meeting you.



Prof. Ming Xu

icRS Conference General Chair

2024 International Conference on Resource Sustainability

(icRS 2024)

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Paper ID: 104

Never let a good crisis go to waste: Greenwashing and the fallacy of critical minerals

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Abstract:

Mining businesses pitch their products as clean energy economy essentials during decarbonization. Demand for "critical minerals" is predicted to rise, yet the role of mining in the clean energy transition and the need for more raw materials are unclear. Despite the unknowns, mining cannot solve climate change. This is "greenwashing." Businesses lie about their environmental efforts to satisfy customers. Most companies that benefit from eco-conscious consumers, from fast fashion to fossil fuels, adopt greenwashing, which can be clever or ridiculous. To claim a company's products or services are "eco-friendly," dishonesty promotes lightweight adjustments. It offers empty promises that need a few business changes. Catchy language and public pledges to increase renewable energy usage may signal that huge oil and gas firms are concerned about climate change while exploiting new resources. Climate change is a business opportunity for mining. Greenwashing as a climate leader justifies dubious aims. Mining corporations sidestep costly and onerous work by greenwashing—diverting one-time environmental actions and "green" marketing. Clean energy transition metals are above ground. Metals are recycled and dumped in landfills outside North America and Europe despite a lack of infrastructure. Increase domestic recycling to reduce metal use. Future demand arguments for greater mining should include long-overdue metal recovery policies and less resource-intensive renewable energy investments. Finally, mining companies must show they want to employ fresh metals for renewable energy. Canadian mine planners must sign a contract to sell domestically. Mining companies will admit sending Australian, North American, and European ore concentrates for processing and smelting. Other than that, the industry's business plan is to tell the public what they want to hear to get the idea approved, keep costs down, and sell to the highest bidder. Until shown by facts and legal commitments, mining industry climate leadership claims are greenwashing.

Paper ID: 106

Socio-Ecological Impacts of Oil Spills on the Niger Delta Ecosystems: A review

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Abstract:

The Niger Delta region has several ecosystems that are vital to the survival of different species and the sustainability of human communities. Among the notable ecosystems are mangroves, freshwater swamp forests, lowland rainforests, and barrier island forests. This paper explains how oil spills in the Niger Delta are a continuing source of environmental degradation and socio-ecological problems in the area. The geological and hydrological characteristics of the delta and the historical pattern of oil spills dating back to the 1950s when oil was discovered in the country are discussed. In order to understand how oil spills impact local ecosystems, I examined the properties of the Niger Delta crude oil blends and their behaviours. Information used in this paper was gathered from primary sources, such as the Nigeria National Oil Spills Detection and Response Agency database, newspaper reports, journal articles, and both published and unpublished research results. I discuss the ecological effects of oil spills, with an emphasis on aquatic habitats and Niger Delta biodiversity. I conclude that oil spills in the region pose a serious threat to the environment and its biodiversity. Hence, stricter environmental protection policies and responsive institutions are necessary for monitoring petroleum operations in the region and protecting its biodiversity.

Paper ID: 111

Agroforestry waste management for biopolymer production following sustainability and green chemistry criteria.

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Abstract:

The excessive consumption of fossil resources, as well as the environmental hazards caused by plastics, have led to the need to propose new bio-based production routes, focusing also on the use of waste resources as raw materials to produce high value-added compounds. In this sense, it is expected that more sustainable, but also more circular, bio-based plastics can be obtained from the valorization of waste from agriculture and forestry waste streams. Within this approach, this research proposes to use poplar wood waste and grape juice waste to obtain the bioplastic Polyethylene Furanoate (PEF), in a cascade process. It starts with initial hydrolysis step to release glucose, an isomerization stage to obtain fructose, and a dehydration step to produce 5-hydroxymethylfurfural (HMF), which will be transformed into 2,5-furandicarboxylic acid (FDCA) by a catalytic process, which is further purified using high-temperature hydrolysis. Finally, the bio-based FDCA is cross-linked with methyl ethyl glycol (MEG) to develop PEF polymerization. The modeling of this process with SuperPro Designer software has been used as background information for the application of the Life Cycle Assessment methodology and the Greenness Grid Index method. The objective of this combined approach is to evaluate the process from the perspective of sustainability, and the degree of compliance with the principles of Green Chemistry. The results are promising under both criteria, although further energy optimization of the process and increased yields of the different stages are key elements in the process towards the production of an even more sustainable bioplastic.

Paper ID: 112

Biofuels for air and maritime transport: sustainable alternatives from the valorization of black liquor

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Abstract:

Increasing the sustainability of the transport sector is key on the advancement on the European Bioeconomy, and the aviation and marine sectors are playing a key role. Looking to decrease the potential emissions, the use of biofuels is a potential strategy. But, to ensure that biofuels could substitute conventional fuels, it is essential to demonstrate its profitability and viability, and in this sense, valorizing waste streams coming from other sectors could help on this challenge. This is the framework of this research report, based on using black liquor (BL) coming from the pulp and paper production to produce biofuel using a hydrothermal liquefaction unit. Three technological designs and production capacities have been considered for the analysis:Case 1 considers full extraction of the oil phase and its upgrading by catalytic hydrothermal deoxygenation, Case 2 considers partially extraction of the oil phase, while Case 3 considers full extraction but without upgrading. Regarding production capacities, low(100 ton/day), medium(300 ton/day) and high-level(600 ton/day) have been considered. Using the data coming from the modelling, the life cycle assessment methodology has been applied, considering both the environmental analysis and the life cycle cost, as well as the circular potential using various performance, resource-flow circularity, and economic indicators. that Case 3 with a production of 300 tons/day presents the least environmental damage, and the highest profitability corresponds to a capacity of 600 tons/day. For the circularity, Case 3 also shows the best performance, given its higher resource productivity and lower energy intensity, among others. The results obtained showed that begging for higher production capacities and a simple, but efficient, process technology is the alternative that promotes higher potentiality for sustainable and circularity approaches.

Paper ID: 121

Integrating circular construction and digital technologies for enhanced resource sustainability

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Abstract:

The global imperative for sustainable resource management demands innovative approaches to construction, as this sector is responsible for significant resource depletion, waste generation and greenhouse gas emissions. Circular construction includes strategies for reusing building materials and elements in order to minimize waste and environmental impact. This approach can be vastly improved through the strategic integration of advanced digital technologies. This paper explores how emerging digital technologies, such as artificial intelligence (AI), reality capture, extended reality (XR) and Geographic Information Systems (GIS), can revolutionize circular construction. A mixed-method approach of literature review, case studies, and expert interviews led to the following results. First, generative AI has the potential to accelerate the design process. Additionally, reality capture and GIS technologies can enable accurate mapping and cataloguing of existing materials and structures for reuse. Finally, XR technologies offer immersive interfaces for planning and visualizing the potential reuse of materials in situ, potentially enhancing decision-making processes. Exploring such an interdisciplinary approach not only supports the sustainable management of physical resources but also has the potential to reduce emissions and waste associated with new material production. By presenting case studies and empirical evidence, this paper demonstrates how the synergy between circular construction principles and digital technologies can lead to significant advancements in resource sustainability.

Paper ID: 124

Spatio-temporal evolution and influencing factors of carbon deficit in Chinese cities

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Abstract:

There is a significant imbalance in carbon emissions and carbon absorption capacity in different regions of China's vast territory. This paper calculates the carbon deficit of 253 prefecture-level cities in China from 2009 to 2019, analyzes the spatial-temporal variation patterns of carbon deficit, and empirically analyzes multiple influencing factors of carbon deficit by spatial econometric models. In terms of time dimension, China's carbon deficit is driven by carbon emissions and has a slow rising trend during the study period. From the spatial dimension, most of the cities with carbon deficit are concentrated in the east of China, showing low carbon emission and low carbon sink. The gravity center of carbon deficit in Chinese cities is concentrated in the junction of Henan Province and Shandong Province, and mainly shows a trend of northwest transfer from 2009 to 2019. There is a significant autocorrelation between urban carbon deficit in China, and the spatial and temporal structure has a strong spatial locking effect and path dependence phenomenon. Furthermore, spatial econometric analysis show that increasing urban green patents will significantly reduce the local carbon deficit. Since most cities in China are still at the left end of the Kuznets curve, the direct influence of wealth on regional carbon deficit is always positive for our sample. There is a U-shaped nonlinear relationship between urban population and China's regional carbon deficit. As to the spatial effects, due to the huge difference in economic development level and the competition effect between regions, the improvement of green technology will increase the carbon deficit of neighboring cities. With the increase of urban wealth in China, factors such as resource allocation and industrial transfer between cities will reduce the carbon deficit of neighboring cities. Some policy implications are put forwarded accordingly.

Paper ID: 125

Enhancing Sharjah Campus Aquaponics's performance for sustainable food security

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Abstract:

An aquaponics system was built as a sustainable, economical, and environmentally friendly method that integrated plant and fish cultivation in a closed-loop system. The objective of this paper is to develop the previous (solar-powered aquaponics system that was implemented within HCT's mobile learning unit at the Sharjah Campus to prioritize water conservation, eliminate reliance on soil, align with United Nations sustainable development goals, and promote sustainable farming practices for robust food production in the UAE) and improve its performance to make it more compact. This was accomplished by switching from a single-layer system to three vertical layers of installation. The pipe system and the layout are not meant to cross or intersect with one another in the new arrangement but also with the management of a better water flow throughout the entire system. With this new layout, the system needs only 2 pumps instead of 3 pumps, hence lower power consumption (40560 Wh/day as opposed to 60840 Wh/d), less PV number (10 PV instead of 14 and 13 batteries instead of 20), and smaller PV installation places. The new total PV installation area is reduced from 50 m2 to 35.75 m2. Hence, the saving area is roughly 71.5% of the original amount. Furthermore, the primary parts of the system are set up and run in an IOT-capable building. Waterbeds, tanks, and pumps are all equipped with WiFi. All system characteristics and parameters are remotely controlled and monitored by this system through switches and sensors and an online mobile application. The primary findings of the study indicated that the pH, temperature, and ammonia levels of the system were monitored every month and were estimated to be 6.4-5.2, 31.8–34.70C, and 1 mg/L-1, respectively. The aquatic life was found to have a daily growth rate of 3.92% and an 83% survival rate.

Paper ID: 126

PIV measurement and simulating flow in solar spheres for power generation

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Abstract:

ANSYS Simulation and Particle Image Velocimetry (PIV) measurements are employed to assess the velocity of the flow field in an acrylic solar sphere containing water. The acrylic sphere, an innovative concentrated photovoltaic device, collects sunlight and concentrates it in a confined region, similar to a focal spot. This focal point is located right above a multi-junction device, which serves as a concentrator cell appliance. A device like this may instantly produce an immense quantity of power, which is then used to produce greater electrical power than standard photovoltaic panels. The transparent acrylic spherical is also utilized for a variety of industrial purposes. The purpose of this research work is to investigate the properties of the flow inside the sphere and how the temperature affects the flow velocity of the fluid motion in order to obtain greater efficiency in power generation and hence enhance performance. The findings demonstrated that the velocity and the temperature had a substantial impact on the flow structure value.

Paper ID: 129

Structural evolution of the global ICT multinational enterprise network and CO2 emission outsourcing

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Abstract:

With the rapid advancement of globalization and the ICT system, multinational enterprises (MNEs) have spurred economic growth while presenting challenges in emissions mitigation. Using the Multi-regional input-output model and complex network analysis, we investigate the characteristics, key nodes, and community structures of the global CO2 emissions transfer network driven by ICT related MNEs (GCNI) from 2000 to 2019. We observed a rise in the network's density and efficiency from 0.48 and 0.82 in 2009 to 0.58 and 0.88 in 2019, indicating heightened interconnectedness and enhanced resource flow within the GCNI post-financial crisis. The network's hierarchy decreased as economies engaged in more equitable and extensive cooperation post-financial crisis. China, Chinese Hong Kong, the United States (US), Japan, South Korea, and Chinese Taiwan held central positions within the GCNI, while small economies played roles by connecting with these powerful regions, forming a core-periphery structure. Over time, the GCNI underwent dynamic cluster adjustments, resulting in two distinct groups by 2019: one dominated by the US, spanning economies across Europe, America, Southeast Asia, and Africa, and another solely dominated by China, encompassing Asian countries. These findings underscore the urgency of enhancing international cooperation to address cross-border environmental challenges in the digital era.

Paper ID: 130

Issues for recovering plastic debris from the ocean floor with fishermen: A study of fishermen's associations and municipal governments in Japan

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Abstract:

Previous studies have shown that ocean-floor plastic debris can be collected with the cooperation of fishermen but requires cost support from local governments and other entities. However, there is insufficient research on how to proceed with plastic debris collection by fishermen, by their resided region, by ocean current area, and by the fishing method used. Therefore, this study compared the impact of plastic debris on fisheries by these categories and the challenges for plastic debris collection in Japanese fishermen's cooperatives. Local government views were also compared by region and by ocean current areas to examine the challenges of collecting plastic debris with fishing cooperatives. Sanyo Techno Marine Co., Ltd, collected the data used for this research as part of the project "Demonstration project for ocean floor plastic debris collection with the cooperation of fishermen in FY 2020," which was administered by the Ministry of the Environment, Japan. This analysis featured 79 fishing cooperatives and 55 local governments. According to the fishing cooperatives, the merits of collecting ocean-floor plastic debris and the willingness of fishermen to participate in the effort vary depending on the ocean's current area. The merits of debris collection also differed between East and West Japan. From the local government's perspective, there were no apparent differences in the willingness of fishermen to participate in plastic debris collection between East and West Japan or between ocean current areas. For effective coordination of fishing cooperatives and local governments to collect ocean-floor plastic debris, not only the cost support but also securing the way to store and dispose of collected plastic debris is essential.

Paper ID: 138

Hydrothermal carbonization of food waste in digestate as reaction media : process optimization and thermal kinetics

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Abstract:

Hydrothermal carbonization (HTC) is a sustainable waste management method; nevertheless, using deionized water in large-scale hydrothermal treatments depletes water resources at an exponential rate. This study explores anaerobic food digestate as an alternate reaction medium for HTC operations. The physicochemical characterization, combustion behavior, process parameter optimization, and life cycle analysis of the hydrochar synthesized from raw food waste (FW) in distilled water (FW+DW) are compared with the hydrochar synthesized in food digestate (FW+DS). The results obtained from the Van Krevelen diagram indicate that synthesized hydrochars fall within the lignite coal range. The findings suggest that the hydrochar derived has the potential to substitute for conventional fossil fuels. The higher heating values of the hydrochars calculated were in the range of 15–25 MJ/kg, similar to those of fossil fuels. Response surface methodology (RSM) was used to optimize two operational variables of the HTC process: temperature and reaction time. The optimal conditions of temperature and time were determined to be 208.3 oC and 116.135 minutes, respectively, for FW+DW, and 213.7 oC and 60 minutes for FW+DS. When combustion kinetic parameters, such as the Comprehensive Combustion Index (CCI), ignition index (Di), and combustion stability index (Rw), were computed, both the FW+DW and FW+DS showed similar combustion behavior, with the hydrochars exhibiting enhanced thermal characteristics compared to raw FW.

Paper ID: 139

Evaluation of municipal organic waste management practices in contributing to the UN SDGs

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Abstract:

The Philippines faces a significant challenge with the rising generation of its municipal solid waste, over half of which is classified as municipal organic waste (MOW). This study evaluates the country's municipal organic waste management (MOWM) framework and assesses the contribution of four MOW utilization methods to the UN Sustainable Development Goals (SDGs). Data were collected from literature review to identify the contributions of the MOWM practices to each SDG. Utilizing the Fuzzy VIKOR-Shannon Entropy multi-criteria decision-making approach, the study analyzes the impact of these practices on economic, environmental, and social parameters. Results show that composting is the most preferred method, followed by anaerobic digestion, landfill gas (LFG) extraction, and refuse-derived fuel (RDF) production. This study concludes that composting demonstrably advances most of the SDGs, fostering progress in health, education, equality, energy, industry, climate change, economic development, and ecosystem health. RDF production, on the other hand, offers substantial employment opportunities, while LFG extraction can facilitate partnerships. Overall, this study demonstrates that integrating these waste utilization methods within the MOWM framework can significantly contribute to achieving the Philippines' economic, environmental, and social development goals as outlined by the UN SDGs.

Paper ID: 140

Decision optimization in the multi-timescale electricity market: Integrating coupled tradable green certificates and green power trade

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Abstract:

Achieving the national climate target would depend on national actions. China has implemented important market mechanisms for a green and low-carbon energy transition, including the Renewable Portfolio Standard (RPS), the Electricity Consumption Guarantee Mechanism (ECGM) for renewable energy, the Tradable Green Certificate (TGC) market, the green power trading market, and so on. However, how to effectively integrate coupled TGC and green power trading to achieve a balance between maximizing economic benefits and environmental friendliness remains to be explored. Therefore, this study extends prior research by establishing a bi-level optimization model to explore market participants' decision making from the perspective of energy supply and economic value, and analyzes the impact of the RPS, TGC price, and the penetration of renewable energy (RE) in the electricity market, the green power market, and the trading strategy of market participants in a multi-market equilibrium state. The feasibility and effectiveness of the bi-level optimization model and algorithm are verified using the example of IEEE14 node and historical data of Elia Energy. The results show that: (1) Under the market equilibrium condition, the clearing price in the RE day-ahead market is equal to the clearing price in the traditional energy day-ahead market plus the TGC price. (2) When green power participates in the spot market, there is a complementary relationship between RE generation and traditional energy generation. (3) A shift from decreasing to increasing cost for electricity consumers when RE penetration is above a certain threshold (α>30%) and the TGC price is 100 CNY/MWh, and a decrease in the growth rate of RE generators' profit when RE penetration is above a certain threshold (α>35%). (4) Traditional energy generators with small installed capacities adopt riskier market behaviors to declare more electricity and try to obtain higher profit in market transactions.

Paper ID: 141

Multi-waste daily time series prediction model with IoT-based collection bin in China

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Abstract:

Municipal solid waste (MSW) management stands as a crucial issue and challenge confronting local governments, encompassing public health, resource cycling, and environmental protection. municipal solid waste generation represents a fundamental and indispensable facet, serving as a basis in operation of solid waste management system. Effective waste management efforts are however hindered by dearth of data and constraints of algorithms. The objective of this study was to develop high-precision models based on IoT collection bins for accurate MSW generation forecasting that enhances operational efficiency of waste disposal facilities and waste management systems. Models were generated by 14,039,838 waste records from 3052 IoT-based collection bin in three cities in China. Three machine learning algorithms including artificial neural network (ANN), long short-term memory network(LSTM) and bidirectional long short time memory(Bi-LSTM) were trialed for their performance of daily multi-waste generation prediction in Guangzhou, China. Models further considered effects of time lag on time-sensitive waste variables. Results demonstrated that deep learning models exhibit excellent predictive capabilities and can be effectively utilized to develop daily MSW forecasting models. Bi-LSTM network exhibited the most accurate predictive performance, minimizing prediction error to 18.7%. The model also demonstrated excellent generalizability and robustness across different cities and time periods by transfer learning. This study has demonstrated the feasibility and reliability of artificial intelligence algorithms in MSW forecasting. The proposed methodology offers a replicable and scalable solution for waste management.

Paper ID: 143

Comprehensive evaluation with technical, economic and environmental perspectives-A case study of MBR technology in rural domestic wastewater treatment processes

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Abstract:

Quantitative assessments the sustainability of rural domestic wastewater treatment technologies is necessary to optimize the treatment process and assure sustainable development. In this research, technology assessment was introduced to the comprehensive evaluation which considering the technology, economic and environmental perspectives for four typical wastewater treatment technologies (i.e., anaerobic/anoxic/aerobic + membrane bioreactor (A2O-MBR), modified A2O-MBR, pre-denitrification-anaerobic-anoxic-oxic + moving bed biofilm reactor (A3O-MBBR), and modified A3O-MBBR). Technology assessment revealed that M-A3O-MBBR was more suitable for rural domestic wastewater treatment. Economic assessment confirmed that M-A3O-MBBR has both the lower treatment cost (71700 CNY) and the best profit (512299 CNY). By comprehensive environmental assessment (CEA), the relative environmental friendliness of rural domestic wastewater treatment technologies are as follows: M-A3O-MBBR (1.72E+10) > M-A2O-MBR (1.73E+10) > A2O-MBR (1.98E+10) > A3O-MBBR (2.21E+10). The comprehensive evaluation performed indicates that M-A3O-MBBR technology performs better than the other technologies in terms of technical performance, economic benefit, and environmental impact.

Paper ID: 144

Experimental and theoretical investigation of drying characteristics of manganese sulfate monohydrate with a fluidized bed dryer

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Abstract:

Manganese sulfate monohydrate, a key cathode material for secondary batteries, needs to be dried to an appropriate amount of moisture content after the hydrometallurgical process in battery recycling. In this study, a fluidized bed dryer was developed for drying wetted manganese sulfate monohydrate and its drying characteristics were investigated. Detailed theoretical investigations demonstrated the drying mechanism of the drying material by considering drying characteristics such as constant-rate and falling-rate drying. Experimental investigations were conducted on key operating parameters such as humidity ratio and pressure using a vertically designed fluidized bed drying module. The drying mechanism of manganese sulfate monohydrate was analyzed based on the physical and thermal properties of the drying material. The BET surface area of the manganese sulfate monohydrate (mean particle size of 0.083 mm) was 2.4 m2/g, with pore sizes ranging from 12.8 nm (for desorption) to 17.1 nm (for adsorption), a pore volume of 0.01 cm3/g, a surface area of 0.2011 m2/g, and a micropore volume of 0.0001 cm3/g, confirming that manganese sulfate monohydrate is non-porous. In addition, the critical moisture content of manganese sulfate monohydrate was approximately 4 wt% (for the constant-rate drying period), and the equilibrium moisture content ranged from 0.10 to 0.66 wt% (for the falling-rate drying period) at temperatures of 25–40°C and relative humidities of 12–60%. It was confirmed that the constant-rate drying time of the drying material decreased from 65 to 38 min with a decrease in the humidity ratio of the inlet air from 13 to 5 g/kgDA, and its value decreased from 53 to 25 min with a decrease in the pressure from 1.0 to 0.4 bar. The experimental results were in good agreement with the developed numerical model, with a coefficient of determination (R2) between 0.96 and 0.99.

Paper ID: 148

The broken promise of triple bottom line approach in circular economy

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Abstract:

This research primarily calls upon the theoretical claim of the significant stabilizing role of business model design in businesses tackling/incorporating new strategic issues (Bocken et al., 2019). Thereby, we initially scope the role business model design is currently playing in strategizing the Circular Economy (CE) in transitioning organizations. The research will further query the various business model design and innovation framework that have been developed in academia and practitioner tools to strategize the transition toward CE principles and embed circularity into the business strategy of existing organisations. This enquiry is not intended to interrogate the specific use of framework or tools, but instead how these tools or frameworks engage, include, and develop the three dimensions - economic, environmental, and societal dimensions in its process as part of the Triple bottom line approach (Elkington, 1998). Initial analysis showed that these tools and frameworks are not paying attention to the social dimension by not integrating it in their design process. Furthermore, this research is also particularly important to future research, as there has been no agreement to measure how effective an industry/product is in making the transition from linear to circular approaches, particularly those that affect society (Rivera et al, 2020).

Paper ID: 149

Synergistic policy impacts: unveiling the transformation of thermal power trading strategies with energy-consuming rights trading and green certificates

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Abstract:

The energy crisis has compelled nations to enhance energy consumption efficiency, bringing energy-consuming rights trading (ERT) policies to the forefront. The implementation of ERT is set to influence corporate production and operational activities significantly. This study, drawing on the current status of ERT pilots, designs a trading mechanism and constructs a four-party evolutionary game model to simulate the impact of ERT on the operational strategies of thermal power enterprises in Zhejiang. We developed 525 distinct policy scenarios, considering variations in exchange rates between energy quotas and green certificates, as well as changes in government rewards and penalties, and selected the optimal configuration via multi-objective optimization. Using optimized policy frameworks, this study examines the interplay of energy quota prices, green certificate prices, and targeted government incentives on stakeholder strategies. By integrating prospect theory, we reveal how risk preferences shape decision-making. Our findings highlight the crucial role of policy cohesion and the stringency of penalty and reward systems in shaping market actors' decisions. Insufficient policy integration leads to sluggish market responsiveness, while robust integration enables policy adjustments to significantly influence corporate behavior. Severe penalties effectively deter non-compliance, preserving market order. Through multi-objective optimization, this study proposes phased policy alignment mechanisms tailored to the ERT market's developmental stages, providing strategic guidance for market inception and future policy adjustments. From a prospect theory perspective, firms dynamically adapt trading strategies based on risk appetites. While direct economic incentives quickly stimulate market engagement, their long-term impact on cost-sensitive firms is limited, underscoring the need for policy designs that balance subsidies with enduring market-based incentives.

Paper ID: 154

Green and low-carbon recovery of critical metal resources in energy materials: a comprehensive technology and evaluation system

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Abstract:

The materials required by energy industry have achieved rapid development and so many kinds of critical metals are required in the complex energy material industry. Many wastes are generally produced in the recycling of energy materials, and the environmental load is heavy with huge pressure of pollution reduction. Therefore, green and low-carbon recovery of critical metal resources in energy materials should be paid special attention for exploring the recycling mechanism, establishing efficient and short-range resource recycling processes. In our research, an effective resource recovery technology and comprehensive evaluation system is established for typical energy material recycling processes. The main contents and conclusions are as follows: For the recovery technology, a recovery process of high purity lithium carbonate from the waste cathode material of spent lithium-ion batteries (LIBs) was developed under the use of formic acid. In the sight of the problem that the recovery of waste cathode scrap is very complex, the recovery process of spent LIBs was analyzed and evaluated comprehensively. It was found that the leaching rate of inorganic acid was stronger than that of organic acid, and all inorganic acids can react with Al completely, while the organic acids can be used to separate the aluminum foil from cathode material. To establish a comprehensive pollution control evaluation system for the entire industrial process, a multi-objective overall optimization is established under economy, environment, and resources perspectives. The whole process economic minimization model was developed based on the material cost, energy cost, water cost and additional cost. The comprehensive environmental impact assessment methodology mainly evaluates the pollutions, combining with life cycle assessment and carbon footprint analyzation. Finally, the green and low carbon evaluation model was established for the typical energy materials (i.e., V2O5, light-emitting diodes (LED)) to guide the classification of recycling technologies and the formulation of comprehensive policies.

Paper ID: 167

A multidisciplinary perspective on social dimension literature in circular economy

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Abstract:

This literature review examines the representation of the social dimension across three important disciplines in circular economy research: science and technology, organizational studies, and social entrepreneurship. By conducting a comparative analysis of prominent research papers and identifying key themes within each domain, the study highlights the varying conceptualizations and prioritization of the social dimension. Science and technology literature primarily focuses on the role of technology in addressing social issues, while organizational studies emphasize the importance of management and stakeholder engagement. Social entrepreneurship research offers a more comprehensive perspective, exploring the interplay between individual and collective elements in driving social change. The review reveals a lack of interdisciplinary integration and identifies opportunities for future research to develop a more holistic understanding of the social dimension's crucial role in the transition towards a sustainable circular economy. The findings underscore the need for a socially inclusive, interdisciplinary approach that leverages the social dimension as a catalyst for transformative change.

Paper ID: 168

Opportunities and Challenges for the Application of Composts from Food Processing Wastes in Environmentally Friendly Techniques

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Abstract:
Managing food processing wastes (FPW) using environmentally friendly techniques is a pressing challenge that requires innovative solutions. According to the United Nations Environment Programme, 931 million tonnes of food are wasted annually worldwide, which is equivalent to one-third of global food production. Meanwhile, the preservation of healthy soil is crucial for the existence of life on Earth as it provides humanity with a range of ecosystem services that enable its survival, from supplying 95% of our food to regulating the climate. In light of the aforementioned, we put forth a groundbreaking approach for the management of FPW. This involves subjecting the waste to composting and utilizing it as an additive to bolster the phytostabilization of soils contaminated with potentially toxic elements (PTEs). Phytostabilization technique have become important tools for controlling the diffusion and migration of PTEs in soil and improving the overall quality of the local ecological environment. In the studies, compost from fish wastes and compost from animal fat residues were used, which were added at a rate of 3% (w/w) to soil heavily contaminated with PTEs from post-industrial areas. The assisted phytostabilization experiment was conducted using F. rubra as the test plant. The total PTE contents in the roots and above-ground parts of the plants and in the soil, were analyzed with FAAS. The study revealed, that composts addition into PTE-contaminated soil increased the relative plant biomass as well as the soil pH value as compared to the non-amended series, whereas the total contents of Zn, Pb, Cu and Cd were generally higher in roots than in the above-ground parts of F. rubra. In particular, the incorporation of compost from fish wastes into the soil contributed most significantly to the considerable relative decrease in the total and bioavailable content of Cu, Pb, Cd and Zn in the soil.

Paper ID: 169

Deep eutectic solvents as essential washing agents in remediation of Cd-contaminated soil

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Abstract:
Soil contamination with heavy metals presents significant environmental risks, particularly with Cd being one of the most toxic metals. Soil washing methods can be utilized to meet quality standards for soil contaminated by Cd, with the effectiveness of the method depending on the choice of washing agent. Conventionally, chelating solutions or biosurfactants have been used, but emerging alternatives such as deep eutectic solvents (DES) exhibit potential due to their simple preparation using natural compounds. The study aimed to assess the effectiveness of removing Cd from contaminated soil using Deep Eutectic Solvents (DES), based on choline chloride-urea, and to evaluate the distribution of Cd in the soil after the washing process. The research was conducted on artificially contaminated soil with a neutral pH and low organic matter content (2.1%), containing 15.6 mg Cd/kg of soil. The soil washing was carried out for 24 hours using varying concentrations of DES (25-250 mM). Additionally, the study investigated the kinetics of metal removal from the soil over different time intervals (0.5-24 hours). Following the washing process, the distribution of Cd in the soil was analyzed using a modified BCR procedure. The optimal concentration of DES for the removal of Cd was established at 200 mM, accompanied by a 4-hour washing period, yielding an efficiency of 87%. After washing, a decrease in Cd concentration was observed in the soil, mainly in the exchangeable fraction (specifically bound) and in fractions associated with amorphous and poorly crystalline, hydrated iron oxides. Thus, DES can be considered for the remediation of Cd-contaminated soils.

Paper ID: 170

Heterogeneous multi-agent simulation and sub-regional policy analysis of the cross-regional recycling system of retired power batteries in China

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Abstract:

Informal recycling of end-of-life electric vehicle batteries has caused severe environmental pollution and tax losses. Linear models and static strategies have difficulty capturing complex relationships and regional heterogeneity. Therefore, we aim to suggest an optimal subregional joint policy under fiscal constraints. This study uses agent-based modeling with geographic information systems to construct a cross-regional recycling system model that assesses the economic and environmental effects of policies. Based on actual data, the model considers four subsystems, multiple region types, two battery types, and six stakeholders. The results show that: (1) The optimal subregional joint policy can increase the average formal recycling rate from 28.44% to 48.58% and achieve an emission reduction rate of 19.81%; (2) In underdeveloped regions, allocating 70-80% of fiscal funds to supervision can achieve optimal economic and environmental benefits; and (3) For the local governments with few formal sectors, investing in a unit subsidy exceeding $1.4/kWh will diminish economic efficiency. Provincial governments in economically developed areas with formal business clusters should provide higher subsidies, while other regions should allocate more fiscal expenditure for supervision. This cross-regional recycling system model can improve solid waste management in countries with large areas and decentralized facilities.

Paper ID: 172

Shale revolution at 15th. The “energy weapon” and the great power competition.

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Abstract:

In 2009, the United States became the world’s largest natural gas producer, and shortly thereafter also the largest oil producer. It went from being a net importer to a next exporter of both commodities. And immediately, a discussion arose about the possible economic and strategic consequences of the shale revolution. The goal of this paper is to answer the question: Fifteen years after the beginning of the shale revolution, what strategic consequences of it can be identified? I argue that, in the face of a growing division of the globe into Three Worlds—West, East and South, the United States has used its resource wealth to wean the global West away from Russian fossil fuels. Paradoxically, this behaviour by the US has also contributed to a consolidation of the global East, as Russia now sees China as its most important economic (and strategic) partner. This paper contributes to the literature on the strategic consequences of the shale revolution. It also demonstrates that de-risking involves not just the high-tech sector , but also the supply of fossil fuels.

Paper ID: 173

Global water scarcity threatens two hundred million employments

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Abstract:

Water scarcity presents a significant global challenge with far-reaching implications for societies. Assessing the potential employment impacts resulting from water scarcity is essential for preserving social stability. Yet the current understanding of the potential employment repercussions of water scarcity remains unclear. Here we aim to quantify the potential employment loss due to local water scarcity and its propagated effect through global supply chain. This study first evaluates water scarcity for each country based on water availability, water withdrawal, and environmental flow requirement. Then, we calculate the potential direct economic loss caused by local water scarcity and quantify the transmission of potential economic loss through the supply chain based on the MRIO model. By constructing the time series regression model, the relationship between economic output and employment by sex is established, allowing for the quantification of potential employment loss. Results show that approximately 200 million jobs (95% confidence interval: 158-233 million) globally, constituting about 5.8% of total global employment, were at risk in the year 2020. Local water scarcity contributed to a potential employment loss of around 137 million jobs, with an additional 59 million jobs propagated through trade. Our analysis also identifies hotspots of potential employment loss for both female and male workers at national and sectoral levels. Notably, there is a distinct inequality in employment loss among countries with varying income levels, and sex-specific variations in employment loss are evident at the sectoral level. These results underscore the multifaceted challenges posed by water scarcity and provide a foundational understanding for countries to formulate strategies aimed at mitigating potential employment loss resulting from water scarcity.

Paper ID: 181

Footprint analysis of circular economy practices in the steel industry

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Abstract:

Steel is one of the dominant materials in the building industry, however, substantial environmental impacts occur in its supply chain. We evaluate the environmental performance of different steel production scenarios at the macro level, taking into account circular economy practices. Using the dynamic life cycle assessment methodology, different scenarios are assessed for the time horizon 2015 to 2070. The environmental footprints are quantified in terms of primary energy, greenhouse gas (GHG) emissions, material, land and water footprints. Forecasts regarding the availability of end-of-life steel and future demand in European and global contexts are considered. The analysis shows potential savings across all impact indicators except for the water footprint. This is because of the projected increased use of electric arc furnaces compared to blast furnaces, leading to increased electric energy demand supplied from hydropower. Within Europe, sufficient supply of end-of-life steel is possible from 2043 on, but complete electrification of the production route, away from fossil fuels, might not be possible until 2070, due to increased demand. Moreover, blast furnace-based steel production assets are relatively new (e.g., average age is 13 years), and therefore, might not be discarded before the end of their useful service life, usually 40 to 50 years. As a result, the emissions associated with these assets could be considered as ‘locked-in’. Accordingly, global steel production is associated with significantly increased environmental impacts.

Paper ID: 182

Two-Step Procedure to Synthesize Carbon Microspheres with High Yields and Monodispersity from Biomass

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Abstract:

Carbon microspheres (CMs) are highly sought after in fields such as catalysis and contaminant remediation. Their synthesis usually involves the hydrothermal carbonization (HTC) of pure carbohydrates with tight control over their concentration and the reaction temperature and retention time. Nowadays, new methodologies are being studied to improve the yield and monodispersity of the CMs. With this objective in mind, fresh apple pomace (AP) and grape pomace (GP) were used in to test a two-step procedure to synthesize CMs with and without additives. The first step consisted in a mild hydrolysis of the biomass to obtain a sugar-rich liquor. The second step consisted in the HTC of the obtained sugar-rich liquors to yield CMs. The mild hydrolysis of the AP and GP was performed at 140 ºC, 150 ºC, and 160 ºC and 20 min, 60 min, and 180 min in autoclave to obtain the sugar-rich liquor. A temperature of 140 ºC and a residence time of 60 min were deemed to be the best conditions for the process on the basis of dewaterability of the solid residue and the lower degradation of the organics in the extract. The filtrated liquors were then subjected to HTC at 180 ºC, 220 ºC, and 250 ºC for 1 h to prepare the CMs. While higher yields were achieved at 220°C and above, the resulting CMs were larger and prone to agglomeration. To reduce the CMs size, and striving towards monodispersity, polystyrene sulfonate (PSS), a polyelectrolyte, was used as additive. With a 1% concentration of PSS, raspberry-like CMs were obtained with increased yields. The yields obtained were 3-times greater than those obtained from a test glucose solution with the same organic carbon content. This research shows the potential of biomass compounds extracts to obtain fine CMs.

Paper ID: 183

How innovation ecosystems facilitate circular economy implementation? System dynamics drivers in the European textile ecosystem

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Abstract:

The transition to systemic circular solutions in the textile industry requires integrating every aspect of the textile value chain, influenced by political, regulatory, socio-economic, technological, and market forces. Europe is expected to implement new regulations under the EU strategy for sustainable and circular textiles, fundamentally changing how textiles are sorted, recycled, designed, manufactured, and handled at their end-of-life. Empirical macro-level studies using supply chain management frameworks have successfully addressed resource recovery challenges. However, strategies like sharing platforms, product use extension, industrial symbiosis, product as a service, circular inputs, and eco-design related to inter- and intra-firm innovation have lagged in scientific studies. The present study proposes a research design based on the ecosystem's theory as an alternative to integrate the systemic approaches to understand the dynamic interaction with the macroenvironmental context, including consumers and users as part of stakeholders, and claiming that Supply chain management framework have failed in addressing the complexity of this issues separately. The study also offers a methodological alternative to address innovation in CE from a systemic perspective, focusing on behavioural drivers of circularity rather than just symptomatic barriers or quantifiable impacts. An expert group of 14 respondents from seven European countries, with expertise across various production stages, contributed to create the matrix of causal relationships between 12 circularity drivers. A Causal Loop Diagram identifying eight key drivers of circularity in the textile ecosystem was proposed. The study identifies three key drivers: 1) the value added of circularity, 2) internationalization, and 3) skills and competences training, as most significant in explaining innovation ecosystems and circularity transitions in the textile ecosystem. The research identifies causal drivers shaping CE innovation transitions, offering an ecosystems-based approach with managerial and policy implications, and provides science-based recommendations on new biochemical recycling technology for textile industry solutions.

Paper ID: 186

The effects and new insights of industrial transformation demonstration zones on environmental pollution in Resource-based cities: Quasi-experimental evidence from China

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Abstract:

Resource-based cities (RBCs) depend on abundant natural resources to contribute to national economic growth; however, unique industrial structures have generated severe environmental pollution (EP) in RBCs. This study focuses on the influence of industrial structure transformation (IST) on EP in RBCs using a difference-in-differences model to examine panel data from 114 Chinese RBCs spanning 2014 to 2021 and China's industrial transformation and upgrading demonstration zones (ITUDZ) as an exogenous policy shock in a quasi-natural experiment. The result demonstrates that IST has significantly lowered EP in RBCs, with persistent impact. The mechanism analysis suggests that IST inhibits EP in RBCs through green innovation and digital transformation. The effect of IST on lowering EP is strengthened by resource dependence and weakened by geopolitical risk. Heterogeneity analysis indicates that IST significantly decreases EP by decoupling RBCs and comprehensive resource attribute cities. This study enriches the relevant research regarding environmental governance in RBCs, and provides valuable insights indicating for promote green development in countries.

Paper ID: 187

Lactic fermentation of thermoplastic starch (TPS)

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Abstract:

With the increasing demand for sustainable materials, thermoplastic starch (TPS) is emerging as a prominent bioplastic. However, its growing presence in waste streams needs effective treatment methods to support a circular economy. This study investigates the potential of lactic fermentation as a viable process for the degradation and chemical recycling of TPS waste. Our research focuses on studying the ability of Lactobacillus amylovorus LAB to ferment TPS and the influence of changes in the formulation of TPS on the outcomes. We also examined the effect of TPS prehydrolyzation under different environmental parameters over time, such as pH, lactic acid production, consumption of total carbohydrates, and biomass generation. Preliminary results indicate that the specific strain of LAB can successfully degrade TPS, leading to the production of lactic acid above 20 g/L. The optimal conditions used were a pH range of 5.5-6.0 and a incubation temperature of 35°C. We studied the differences in the outcomes by varying certain aspects of the formulations and processes of the bioplastics. For example, we tested TPS with different concentrations of filler (CaCO3), different processing methods, and the influence of prehydrolyzation of the sample before the fermentation process. The outcomes of this study highlight the feasibility of using lactic fermentation as a method for TPS waste treatment and chemical recycling in a circular economy. This approach not only aids in the degradation of TPS but also produces valuable by-products like lactic acid, which can be used in various industrial applications. Integrating lactic fermentation into waste management systems presents a promising step towards achieving a sustainable circular economy for bioplastics.

Paper ID: 188

Impact of bioplastic design on anaerobic biodigestion treatments

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Abstract:

In recent years, the imperative to reduce the environmental impact of plastics has led to regulatory measures such as bans or taxes targeting conventional, petro-based, and non-biodegradable plastics. These actions have boosted the use of bioplastics, both bio-based and biodegradable variants, increasing their presence in municipal waste streams. The current research landscape in bioplastic formulation predominantly centers on their degradation while maintaining good performance, promoting a linear economy where products are discarded as waste. To transition towards a circular economy and improve bioplastic waste management, it is crucial to focus on formulation and design. Anaerobic digestion offers a sustainable pathway to reintegrate used bioplastics into the circular economy, producing biogas, a high-energy fuel, and digestate for other applications. Our research aims to integrate bioplastics into a circular economy by ensuring efficient behavior in anaerobic digestion plants for biogas production. We focused on bioplastic formulation and design to optimize waste treatment processes. The biodegradation rate, a crucial parameter for industrial efficiency, was investigated in thermoplastic starch (TPS) blends, and Polyhydroxybutyrate (PHB) potential replacements for polystyrene and other conventional plastics in single-use items. Key characteristics studied included filler concentration, film thickness, and starch origin. Calcium carbonate was examined as a filler due to its widespread use in the plastic industry. Film thickness determines application suitability and starch origin affects the amylose-amylopectin ratio, influencing plastic properties. Biogas production assessments were conducted under mesophilic conditions (35°C). Kinetic differences were observed in all studies except for starch origin. Results indicated that biogas production speed is inversely proportional to filler concentration and film thickness. The starch source did not significantly affect methane production speed. Methane yield from our samples aligned with the average range observed in municipal solid waste anaerobic digestions.

Paper ID: 189

Uncertainty evaluation and compensation for reservoir's bathymetric patterns generated using conventional depth acquisition and spatial interpolation methods

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Abstract:

Precise measurement of reservoir's bathymetry is crucial for monitoring underwater topography, sediment movement, and quantity of deposited sediment. The current study is aimed at evaluating and compensating uncertainties associated with bathymetric patterns constructed using spatial interpolation based on traditionally acquired water depths data. In this study, a total of 106 reservoir's bathymetric data were randomly collected across various parts of the Kat River Dam. The dataset was divided into three parts: 63 points (60%) were used to generate spatial continuity in bathymetry with geostatistical techniques, 27 points (25%) were used for validation and bias correction, and 16 points (15%) were used to test the bias corrected bathymetric patterns. The Inverse Distance Weighting (IDW), the Ordinary Kriging (OK), the Universal Kriging (UK) and the Regression Kriging (RK) were applied to generate spatial patterns in bathymetry. continuity maps of estuarine TDS levels. The constructed patterns were validated using the validation dataset as input into the R-squared and Relative Error of Mean (REM) methods. The local bias correction technique was applied to minimize reduce discrepancies between predicted and observed bathymetry. Prior to bias correction, the IDW, OK, UK and RK underestimated bathymetry by -14.307%, -9.555%, -10.389% and -10.165% respectively. Post bias correction process, the IDW and RK underestimated bathy predicted by at random locations by -3.22% and -2.16% respectively , and OK and UK overestimated bathymetry by 1.41% and 2.11% respectively. By integrating local correction method with geostatistical interpolation methods, bias in the interpolated bathymetric patterns were minimized. This research highlights the ongoing importance of geostatistical methods in addressing water quality and quantity monitoring issues, which hamper the estuarine water management strategy.

Paper ID: 190

Land use and renewable energy development for carbon neutrality in the Greater Bay Area

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Abstract:

This study examines energy infrastructures and the prospects of economic geography under two major carbon neutrality scenarios with a geographical focus on Hong Kong and Guangdong province that accounts for over 10% of China's GDP and energy consumption. Fossil-fuel infrastructures – including power plants, pipelines, terminals, tankers – account for a lion's share of China's (or many other countries') energy infrastructure asset values at present. For meeting all additional electricity demand in future years (including electric vehicles), the first scenario exclusively relies on wind and solar, and two others scenarios adopt only coal and natural gas-fired power plants with CO2 capture and storage (CCS) (in the second scenario) and nuclear energy (in the third scenario). More scenarios could be constructed through combining the pathways. Our research shows that fossil-fuel infrastructures are disproportionally located in relatively wealthier regions, while renewables infrastructures are more concentrated in relatively poorer regions, as partly driven by their land/coastal water values. Fossil-fuel infrastructures tend to be significantly less asset/capital-intensive than those of renewable energy. The renewables scenario will contribute to the alleviation of regional economic disparities, while the CCS scenario will have opposite effects. The nuclear scenario is about in between. Most asset values of current fossil-fuel infrastructures, either already in operation or planned to be, will be depreciated or written off before China's planned carbon neutrality goal in 2060.

Paper ID: 192

Does technological progress mode affect just energy transition? A seemingly unrelated regression analysis based on Chinese provincial panel data

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Abstract:

Just energy transition (JET) refers to the process of shifting from fossil-fuel-based energy systems to more sustainable and renewable energy sources in a manner that is inclusive and socially fair. Technological progress is a key driver of the energy transition. Selecting an appropriate technological progress mode (TPM) to drive JET that harmonizes environmental conservation with employment stability is crucial for economies to achieve sustainable development. Based on seemingly unrelated regression (SUR) analysis, this research uses provincial panel data of China from 2001 to 2020 to examine the effects and underlying mechanisms of various TPMs on JET. We first construct a translog cost function incorporating four TPMs, including technology import, technology transformation, cooperative research and development (R&D), and independent R&D. The study then systematically estimates and contrasts the factor bias and utilization tendencies associated with these TPMs. The findings indicate that (1) technology import does not directly facilitate JET as it leads to neutral technological progress; (2) technology transformation and cooperative R&D, associated with energy-biased technological progress, exhibit a tendency toward energy use and labor saving, which hinders JET; (3) independent R&D, linked with labor-biased technological progress, demonstrates a labor-using and energy-saving orientation, which supports JET; (4) the adverse effects of technology transformation and cooperative R&D on JET can be mitigated through enhanced environmental regulation, increased environmental taxation, and the provision of low-carbon subsidies. We offer policy recommendations for the Chinese government in promoting TPMs that foster JET while also providing insights and experiences that are beneficial to economies at various development stages in their pursuit of JET.

Paper ID: 195

Exploring Circularity in Italian Textiles: Findings from the RESTART Survey

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Abstract:

This paper presents preliminary findings from a survey investigating sustainability, circularity, and resilience in the Italian textile supply chain. With 230 responses collected so far, the survey provides insights into current practices, challenges, and opportunities faced by industry stakeholders. The survey (i) gathers data on the use of recycled materials, renewable energy, waste management, environmental assessments, certifications, and investments in sustainability; (ii) examines market positioning and the contribution of certified/recycled products to company turnover; (iii) details the company's production structure and involvement in recycling activities; (iv) assesses supply chain relationships based on information exchange, operational linkages, legal bonds, cooperation, and relationship-specific adaptations, (v) explores merger and acquisition activities and interest in vertical integration, and (vi) investigates services supporting circular transition. The data reveals a growing awareness and adoption of sustainable practices, although significant barriers related to cost, buyer-supplier relationships, and technology persist. This study offers a valuable foundation for future research and policy-making aimed at fostering a more sustainable and resilient textile.

Paper ID: 196

Application of fruit tree pruning residues and sweet potato shochu lees in edible mushroom cultivation

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Abstract:

We have been conducting research with the aim of utilizing hitherto unused agricultural resources in mushroom cultivation. In Japan, approximately 322,000 tons of fruit tree pruning residues are generated annually. These residues often contain agricultural pesticides. Therefore, there were concerns about their use in edible mushroom cultivation. This study aimed to create substrates for the cultivation of mushroom, specifically Auricularia polytricha, using mandarin tree pruned branches and sweet potato shochu lees, a byproduct of spirits, and to evaluate whether the fruitbodies are safe as food. Experimental trials showed that using fruit tree pruning residues resulted in higher accumulative yields of mushroom fruitbodies compared to a control substrate of broadleaf tree sawdust. Analysis of general composition indicated a slight increase in protein content and a decrease in carbohydrates in the fruitbodies cultivated with pruned branches. LCMS/GCMS analyses of pesticide in substrates and mushroom fruitbodies revealed that post- sterilization substrates contained residues of 15 out of 200 pesticide types in the range between 0.06 and 2.2 ppm dry weight. After 60-days mycelium growth, these residues decreased to 6 types in substrates before fruitbody formations. The detected pesticides (five of the 6 ones) typically exhibited complex structures involving both benzene and heterocyclic rings. In fruitbodies cultivated with the pruned branches, only boscalid, an acid amide fungicide with anilide skelton, was detected at 0.03 ppm (dry weight) and 0.003ppm (fresh weight) . Although no specific regulatory limits exist for boscalid in edible mushrooms, applying a uniform standard from food safety regulations (0.01 ppm fresh weight) suggests safe levels well below the acceptable daily intake (ADI) of 0.044 mg/kg body weight/day (2.64 mg/day/60 kg individual). Overall, these findings indicate a promising possibility to utilize fruit tree pruning residue and shochu lees for sustainable mushroom cultivation if pesticide residues can be managed to ensure food safety.

Paper ID: 197

Utilization of black soldier fly larvae for organic solid waste management in a landfill in Malaysia

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Abstract:

Black soldier fly (Diptera: Stratiomyidae) larvae are classified as generalist feeders because they have been reported to feed on various food substrates, including food waste, sludge, and fecal materials. Due to their feeding preferences, it is proposed that they could be used in landfills for the management of organic solid waste. Landfilling has been a main waste disposal method for a few decades; however, it has become a problem recently due to the availability of land, environmental pollution, and public health issues. To mitigate these challenges, a laboratory-scale experiment was conducted to evaluate the potential of black soldier fly larvae in reducing organic solid waste from landfills. Seven groups of feeding substrate: - one control group and six treatment groups (i.e., fresh waste, old waste, sludge, 25% sludge+75% old waste, 50% sludge+50% old waste, 75% sludge+25% old waste) with the weight of 2.5±0.02 kg each were supplied to ~2,750 black soldier fly larvae in a plastic container. The larvae were allowed to feed for 29 days before harvesting. The performance of the black soldier fly larvae was evaluated by calculating the waste reduction (% dry matter), bioconversion rate (% dry matter), and waste conversion efficiency (% dry matter). The results showed that the waste reduction was in the range of 41–56%, with no significant differences ($p>0.05$) between all groups. Bioconversion rate and waste conversion efficiency showed a significant difference between the control and the mixture of 75% old waste with 25% sludge. Based on the findings, the application of black soldier fly larvae was found promising in the management of organic solid waste. However, further studies and considerations need to be made before large-scale application, which are also discussed in this research.

Paper ID: 199

Antioxidant, hypoglycemic and efficient degradation of organic dye pollutants in water systems by selenium nanoparticles of hesperidin

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Abstract:

Nanotechnology has opened several applications in engineering, waste management and biomedical science. Nanoparticles are the preferred nanotools due to their stability, reduced toxicity, improved therapeutic activity, bioavailability, biocompatibility, and targeted delivery efficiency to desired sites in the body. Metal nanoparticles of inorganic metals have unique electrical, magnetic, optical and physicochemical properties, making them superior to bulk metals. Selenium is a trace element that plays a significant role in our physiological processes involving enzymes. Selenocysteine, made up of selenoproteins, is the 21st amino acid that maintains oxidative stress and selenium homeostasis. Selenium nanoparticles are less toxic than inorganic selenium, which has a narrow therapeutic index and high toxicity. In this study, we designed selenium nanoparticles conjugated to hesperidin (HSP-Se NPs) as a drug carrier system. The HSP-Se NPs were synthesized using a chemical reduction method and characterized by UV-visible spectroscopy, FTIR, DLS, and HRTEM-SAED. The efficacy of the hesperidin-selenium nanoparticles was assessed towards biomedical application and wastewater management. In-vitro free radical scavenging models of DPPH and ABTS evaluated the antioxidant efficacy of HSP-Se NPs. In-vitro studies on inhibiting diabetic enzymes like α-amylase, α-glucosidase and xanthine oxidase showed a significant decrease ($p < 0.05$). The exhausts from industries using the dye are non-biodegradable, so different physical and chemical treatments were adopted for wastewater management. Hence, in our study, we included some anionic azo dyes like methyl orange and bromophenol blue, cationic dye methylene blue, and nitro compounds like 4-nitrophenol and studied the kinetics of their degradation and reduction in the presence of sodium borohydride as reducing agent and HSP-Se NPs as nanocatalyst at their λmax in UV-visible spectrophotometer. The study concludes that conjugating the selenium nanoparticles to hesperidin, a bioflavonoid can be used to manage different oxidative stress-induced diseases like diabetes and management of wastewater treatment.

Paper ID: 200

Life cycle carbon footprint analysis and exploration of low-carbon strategies for footwear products

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Abstract:

As the footwear industry experiences rapid growth, footwear products consume more materials and energy, resulting in higher carbon emissions. At the same time, with the gradual promotion of green consumption and increasing consumer awareness of low-carbon and environmental issues, the carbon footprint of footwear products is becoming an increasingly important criterion in consumer choice. Therefore, accounting for the carbon footprint of footwear products has become crucial. However, due to the diverse structures, complex raw materials, long production chain, inconsistent energy measurement, intricate allocation among products, and difficulties in tracking recycling and disposal management, revealing the carbon footprint and resource consumption of footwear faces significant challenges. This study established a foundational data inventory, conducted material and energy flow analyses, and developed a comprehensive carbon footprint accounting method that covered the entire life cycle of footwear products, along with calculating other environmental impacts. Furthermore, the study conducted an empirical analysis of two typical footwear products, assessed the life cycle carbon footprints, evaluated various resource recovery scenarios—including material and energy recovery—and identified opportunities to reduce carbon emissions within the supply chain and related departments, thereby supporting the sustainable design of footwear products. Key findings include: (1) Over 75% of carbon emissions stem from energy use in raw materials and manufacturing; (2) The complex material composition of footwear complicates accurate assessments. A comparison of impact factors from various databases shows a -5.2% to 9.6% variation in total carbon footprint; (3) Carbon footprint calculations based on nameplate energy values are 30.8% to 45.0% higher than those based on measured values, which is crucial for accurate modeling; (4) Beyond eco-design, renewable energy use and material recycling can further reduce the carbon footprint of footwear.

Paper ID: 202

Carbon footprint of plastic packaging waste recycling systems with different collection routes

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Abstract:

To transition to carbon neutrality, the establishment of a circular economy through recycling, in addition to reducing the use of plastics, is an urgent issue. Households that discharge and sort plastic waste represent a critical factor in expanding the use of recycled plastics. In the present study, we aimed to calculate the carbon footprint of a recycling system for plastic packaging waste, considering the differences in collection routes. The starting point of the life cycle is plastic packaging waste from households. Differences in the amounts of plastics collected and recycling methods with regard to different collection routes, such as municipal and community collection, were discussed based on questionnaires for residents and interviews with local municipalities and recyclers. The carbon footprint was calculated using the Life Cycle Assessment (LCA) method, considering the recycling of plastic packaging waste for each collection route. The impact of different collection routes on recycling was discussed. A web-based survey was conducted among 1,652 residents of Kobe City, Japan, to determine the collection route used when discharging plastic packaging waste and the degree of washing at the time of sorting. The results showed that approximately 76% of the respondents chose to have their municipality collect plastic packaging waste as recyclable waste when plastic packaging waste is discharged at home. In recent years, resource collection stations have been established in Kobe City; however, the number of users was limited to approximately 1%. Moreover, 19% of respondents chose combustibles, indicating that there is still room to increase the amount of waste collected as recyclables. The respondents were also asked about the degree to which plastic packaging waste was cleaned when it was discharged. Using municipal collection as the standard, the degree of washing was found to be higher for community collection than for municipal collection.

Paper ID: 203

The exploration of advanced decarbonization of China's low-carbon industrial parks driven by scope 3 carbon emissions

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Abstract:

There're > 2500 national and provincial industrial parks (IPs) in China, encompassing > 80% of China's industrial enterprises. The decarbonization of IPs is crucial to low-carbon transformation of China's industry. This study reviews state-of-the-art scientific research and policy practices in recent 5 years through descriptive, bibliometric, and manifest content analysis. It is found that most of IPs' low-carbon development studies and policies focus on direct emissions (scope 1) and indirect emissions caused by purchased electricity and heat (scope 2), while other indirect emissions (scope 3) are often overlooked. However, scope 3 emissions are critical drivers of industrial carbon reduction and are integral to product carbon footprints and green supply chain management for enterprises in IPs. To address this gap, the study proposes a new low-carbon management cooperation model, in which enterprises provide low-carbon solutions while the IP's government leverages its information advantages to identify factories and enterprises with carbon reduction potentials. The IP's government and enterprises jointly invest in low-carbon transformation outside the IP to achieve scope 3 carbon emissions reduction, and the benefits are shared among various stakeholders. Furthermore, an empirical analysis was conducted based on the cooperation practice of gas-to-electricity projects in Chongqing Economic and Technological Development Zone. It was found that the gas-to-electricity projects could achieve 7.59-26.62% scope 3 carbon emission reduction, and the annual operating costs can be reduced by 0.305-1.306 million yuan even without carbon credits. Finally, the study analyzes the policy, management and technical risks associated with promoting this cooperation model. Through game theory methods, it preliminarily explores the distribution of responsibilities, risks, and benefits among different stakeholders in this cooperation model. This research aims to bridge the gaps between IPs' low-carbon development and enterprises' carbon footprint management, supporting the advanced decarbonization of low-carbon IPs through economically, technically, and managerially feasible pathways.

Paper ID: 206

Robust assessments of lithium mining impacts embodied in global supply chain require spatially explicit analyses

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Abstract:

Lithium is a critical material for the energy transition, but its mining causes significant environmental impacts, which will intensify due to surging global demand. Here, we conduct a mining site-specific environmental impact assessment of lithium at global scale, focusing on greenhouse gas (GHG) emissions, water use, and land use. We then track the production and international trade flows of all lithium-containing commodities to assess how lithium mining impacts are distributed across global supply chains. Results indicate that in 2022, 183 kilotons of lithium minerals were extracted and processed in downstream markets, which required 434 million m3 of water, 7,127 km2 of land, and emitted 4,146 kilotons of CO2-equivalent GHG emissions. Depending on the specific mine location, environmental impact intensities of lithium mining differ between several to over 3000 times. 56%-68% of environmental impacts were embodied in internationally traded commodities. On the production side, China, Australia, and Chile were the top-3 countries accounting for 91%-94% of environmental impacts. Regarding final demand, China was the major consuming region, inducing 46%-47% of the environmental impacts of global lithium mining, followed by Korea (17%-18%) and the EU-27 (9%). Our findings reveal the need for spatially explicit information to accurately assess the environmental impacts of lithium mining and highlight that mitigation requires cooperation between major producer and consumer countries.

Paper ID: 207

Recovery of fluorine from rare-earth wastewater with high contents of fluorine and chlorine through crystallization of cryolite

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Abstract:

The recovery of fluorine from high-fluoride industrial wastewater through cryolite crystallization not only reduces fluorine emissions but also recovers value-added fluorine products, making it a sustainable method for the management of fluoride-containing wastewater. The fluorine concentration in the rare-earth wastewater can reach up to 8 g/L, and the chlorine concentration can also reach 30 g/L. Chlorine and fluorine belong to the halogen family. High chlorine concentrations may potentially affect cryolite crystallization and product purity. Therefore, this study investigated the recovery of fluorine from rare-earth wastewater with high fluorine and chlorine contents through the crystallization of cryolite. Results showed that the impact of high chlorine concentrations on the fluorine removal efficiency was not significant while the product purity was slightly reduced with high chlorine concentrations. Under optimized conditions, the fluorine removal efficiency could reach 99%. The solubility product constant of cryolite under high chlorine conditions was measured to be $10^{-33.653}$. Based on this measured solubility product constant, a chemical model was established in Minteq software to estimate the removal efficiency of fluorine through cryolite crystallization, and the fitting results were well validated with the experimental results, better revealing the mechanism of cryolite crystallization process based on reaction equilirbium. In a fluidized bed crystallizer, the linear growth rate of cryolite crystals increased first and then decreased with increasing upflow rate. When the upflow rate was too high, the crystals broke, which was not conducive to agglomeration. The suitable upflow rate was determined as 400 cm/min, and the average particle size of cryolite particles obtained from the fluidized bed crystallizer operated for 3 days reached 233 μm. Therefore, it is technical-feasible to recover fluorine from rare-earth wastewater with high contents of fluorine and chlorine through crystallizaiton of cryolite.

Paper ID: 208

Operative mechanisms for industrial symbiosis initiatives in textiles: towards a new typology

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Abstract:

The textile industry is responsible for about 2% of global greenhouse gas emissions. Significant energy, water, and chemicals are used throughout its supply chain, raising serious environmental concerns. These issues are intensified by increasing amounts of industrial and post-consumer textile waste generated during manufacturing processes and due to consumer habits. Unfortunately, only 20% of this waste is recycled worldwide, mostly for downcycling options. To tackle these challenges and align with circular economy principles, industrial symbiosis offers a promising solution by converting textile waste into valuable resources. Recent scientific literature has explored industrial symbiosis in the textile sector, but in a fragmented manner. Additionally, the existing literature on industrial symbiosis lacks frameworks for categorizing such initiatives, especially within specific industries and lacking the adoption of a supply chain perspective. This paper addresses this gap by proposing a detailed typology for classifying industrial symbiosis initiatives in the textile industry. The proposed typology is developed based on a review of extant taxonomies on the subject and validated with both primary and secondary case studies, ensuring its relevance and applicability. By offering a structured classification system, this paper enhances the understanding of industrial symbiosis initiatives within the textile industry. Lastly, this typology serves as a valuable tool for textile companies, aiding them in comprehending and implementing industrial symbiosis. In this way, it supports the transition towards more sustainable operations, helping the industry reduce its environmental impact and better adhere to circular economy principles.

Paper ID: 211

Comparative analysis of timber carbon stock flows and scenario assessment between China and North America

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Abstract:
Timber, as a critical component of the carbon cycle within forest ecosystems, plays a pivotal role in the flow and stock of carbon within these systems. Meanwhile, the timber industry is integral to national economic development, generating employment, stimulating local economic growth, and enhancing the value of associated industrial chains. Simultaneously, timber serves as a vital raw material for economic advancement globally. Variations in supply and demand across different countries and sectors result in trans-regional flows of timber, consequently leading to shifts in timber carbon stock. Notably, China, the United States, and Canada are major players in the global forestry industry. The timber trade among these three nations has been exceptionally close, with each country complementing the others in terms of forest resources, timber supply and demand, and forestry industry development. This trade relationship not only fulfills the economic development needs of these countries but also fosters cooperation and exchange in sustainable forestry management and environmental protection, contributing positively to global ecological conservation efforts. This study aims to quantify the flow of trade-embodied timber carbon stock between China, the United States, and Canada, analyzing the characteristics and changes in these flows. Using structural path analysis, the study performs a comparative analysis of specific flow patterns of trade-embodied timber carbon stock among sectors in these three countries. Additionally, the research incorporates scenario analysis concerning circular economy policies to account the flow of timber carbon stock in China by 2060, considering various timber recycling rates. This analysis will elucidate the specific changes in flow patterns under different scenarios. This comprehensive approach not only enhances the understanding of carbon stock dynamics in the timber trade between China and North America but also provides insights into the potential impacts of improved timber recycling rates on the future flow and distribution of timber carbon stock.

Paper ID: 213

How do Feed-in tariff and Renewable portfolio standards affect social welfare in China's electricity market based on Carbon emission trading

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Abstract:

To achieve dual-carbon targets and promote a low-carbon energy transition, China has initiated carbon emissions trading (CET) in the electricity sector. Concurrently, China is implementing renewable energy development policies, including feed-in tariff (FIT), renewable portfolio standards (RPS) and related green certificate trading mechanisms. However, theoretical research on CET-FIT is scarce, and more importantly, there is no literature on the social welfare effects of the combined strategy of CET-RPS and CET-FIT in China's electricity market. This paper constructs an electricity producer model that reflects the structural characteristics of the electricity market under the combined policies of CET-FIT and CET-RPS. Through theoretical analysis, we compare the impacts of different policy combinations on the development of the renewable energy industry, carbon emissions and social welfare. The results show that: (1) Under CET-FIT, carbon emissions are best controlled in the early stages of renewable energy development and renewable energy production is highest in the later stages; the opposite is true for CET-RPS. (2) Under CET-RPS, the competitive market structure consistently controls carbon emissions better than the oligopoly market, while the oligopoly market is more advantageous in terms of renewable energy production. (3) Social welfare under CET-RPS is consistently higher than under CET-FIT. (4) Under CET-RPS, the oligopoly market improves social welfare more effectively than the competitive market. These findings provide policy recommendations for optimizing the electricity structure and improving social welfare.

Paper ID: 215

Pathways to carbon neutrality in construction industry: knowledge spillovers from green innovation

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Abstract:

Green innovation is recognized as a viable strategy to address the tension between industrial transformation and pollutant emissions. However, the construction industry has historically shown lower demand and acceptance of innovation compared to other technology-intensive sectors. The extent to which the recent surge of green innovation in construction has effectively reduced carbon emissions remains unverified. This study examines the impact of green innovation on carbon emissions in 171 Chinese cities from 2013 to 2021, measuring it through the exploration and exploitation of green innovation knowledge. The findings suggest a negative correlation between carbon emissions and the exploration of green innovation knowledge, while exploitation shows no significant relationship. The study also highlights a positive correlation between the exploitation rate of green innovation and innovation quality in the construction industry. These results indicate a potential coincidental rather than causal relationship between carbon emissions and green innovation. Policy inducement has led to the proliferation of immature technologies that lack practical implementation. The study emphasizes the challenges of achieving sustainable development in the construction industry, urging policymakers to consider effective implementation of green technologies.

Paper ID: 216

Multi-agent game analysis of agricultural catastrophe risk transfer and sustainable economic development in uncertain environments

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Abstract:
To promote sustainable economic development in agriculture and transfer agricultural disaster risks in uncertain environments, many countries have adopted agricultural insurance as a key solution. However, traditional agricultural insurance faces challenges such as difficulty in loss assessment, high costs, and moral hazard among farmers, which hinder its promotion and negatively impact the agricultural economy. This study constructs a game model among multiple stakeholders involved in agricultural production under uncertain conditions. It innovatively extends the "principal-agent" model from game theory and develops an asymmetric information game model involving farmers, insurance companies, government agencies, and markets to promote sustainable agricultural insurance and economic development. By establishing a mathematical multi-agent game model, this study analyzes the incentive effects of government policies on farmers' production enthusiasm, addresses the pain points of loss assessment for agricultural insurance companies, and explores the potential of using capital markets to transfer agricultural catastrophe risks. The research emphasizes innovative insurance contract design between agricultural insurance companies and farmers to solve the problem of loss assessment. We propose a design that links the compensation mechanism directly to agricultural yields, avoiding the complexity and high costs of traditional loss assessment processes. The results show that relying solely on premium subsidies and agricultural insurance does not significantly increase agricultural production. Instead, increasing retained earnings can enhance the expected or certain income of agricultural enterprises. Additionally, the mathematical analysis demonstrates the importance of establishing policy-oriented agricultural insurance companies. The study also finds that the government should focus on increasing direct subsidies to agricultural enterprises to effectively boost agricultural production. Based on these conclusions, the study offers targeted policy recommendations, including risk diversification through financial market instruments and the use of innovative financial tools to achieve risk transfer and dispersion, thereby comprehensively improving the expected and certain income of agricultural enterprises.

Paper ID: 217

The future of recycling rigid polyurethane foams

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Abstract:

The Global polyurethane (PU) market size accounted for USD 78 Billion in 2023, growing at a CAGR of around 4.5%. Rigid PU foams captured 31.42% of the total polyurethane market in 2023 as they are very valuable for their contribution to the environment as high performance insulation materials, maximising building, and appliance energy efficiency. To date, landfilling and incinerating are the most used routes to dispose of rigid PU foam waste. To achieve a circular economy for PU foams, novel recycling methods are highly needed. Although chemical recycling of flexible PU foams by means of amino-, hydro- or alcoholysis has been known for decades, success for rigid foams has been limited to production waste depolymerised to a low-grade polyol due to their chemical composition. To chemically recycle rigid PU foams into high-quality raw materials for PU production at an industrial scale, a novel and innovative approach must be found. This will be achieved by creating a split-phase process to obtain purified polyols and isocyanate derivatives, or by separating the polyols from the mixture by energetically favourable separation methods. Successful developments have been made by changing the recycling process, which results in the direct separation of the polyols. Additionally, further improvements have been made for the further purification of the polyols, producing virgin-quality polyols. As the initial depolymerisation step takes place at around 200°C, the chemical reactions and clean-up to industrial quality will be assessed from an energy aspect. An integrated techno-economic process optimisation approach will be used in order to assist in the design of, and evaluate the economic feasibility of the chemical recycling process. This will lead to an economical optimised full-scale recycling facility for rigid PU foams, which then can be extended to other PU waste recourses.

Paper ID: 218

An analysis to motivate fishermen in benthic plastic debris removal

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Abstract:
Amid growing global concerns about the impact of marine plastic debris on ecosystems and environment, fishermen are expected to bring debris caught in their fishing gears while fishing back to land for proper disposal. Although 20 to 30 % of marine debris originates in the ocean, the rest is brought by land-based activities, affecting fisheries in various ways, including damaging fishing grounds, gears and vessels. In Japan, it is said that fishermen initiated the volunteer activities of removing marine debris in the Seto Inland Sea in the 1970s, and a coordinated system involving fishermen, fisheries cooperative associations and local governments has been established in limited areas. However, a comprehensive survey on the stranded, drifting and benthic marine debris removed by the fishermen across Japan was not conducted. This study aims to analyze the motivation of fishermen for debris removal. It also explains the results of 462 responses from a questionnaire sent to all 1044 fisheries cooperative associations along the coast between 2023 and 2024, excluding Fukushima prefecture. It was found that 90% of the fisheries cooperative associations experienced damage to their fishing activities, with line fishing, aquaculture, fixed nets, gillnetting and bottom trawling being the most affected. The damages and impacts of benthic debris on fisheries remain uncertain. Regarding removal, 90% of the associations have conducted activities, with 81%, 74% and 54% reporting that fishermen have removed stranded, drifting and benthic debris, respectively. The highest motivations for these activities are to protect fisheries resources, marine ecosystem and environment, followed by providing safe and secure fish production for the nations. The deteriorating marine environment, fishermen's efforts and damages caused by the debris should be disseminated to raise public awareness and stop the flow of debris from land to the ocean.

Paper ID: 223

Debonding on demand of additively manufactured sandwich structures – a multi-domain index calculation

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Abstract:

In the face of prolonged resource depletion and increased waste generation, the implementation of circular concepts has become imperative. However, the primary focus within scientific and industrial spheres tends to be on high-level conceptual, economic, or logistical implementations. At the product level, it is crucial to conduct a precise technological feasibility study and assessment of circular strategies across multiple domains to facilitate the transition towards resource optimization and waste reduction. This study proposes a Debonding on Demand (DoD) sandwich structure, which comprises an additively manufactured Polypropylene (PP) honeycomb core and glass fiber prepreg embedded in a PP matrix. To demonstrate the circular approach, a debonding step based on a well-defined heat treatment step was performed following a service-life simulation that included UV light exposure, temperature exposure in a climate chamber, and a saltwater test. Subsequent to this, the thermo-mechanical recycling of the core structure, as well as re-printing and re-assembly with the glass fiber prepreg, was carried out. Both virgin and recycled sandwich structures were evaluated using a variety of mechanical (ASTM 273, ISO 4624) and rheological (ISO 1133) tests. Alongside the collected manufacturing data, a disassembly index was developed to assess multi-component products. The results demonstrate the potential of adaptable, additively manufactured sandwich structures based on thermoplastic materials. The debonding mechanism and thermo-mechanical recycling enable the reutilization of the core material with comparable properties. The proposed multi-domain disassembly index serves as a comprehensive tool to evaluate the feasibility of products or material combinations after their service life and can support the transition towards a more data-driven circular engineering approach.

Paper ID: 224

Interprovincial transfer of Food–Energy–Water demand and supply in China using a Multi-Regional Input–Output approach

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Abstract:

Food-Energy-Water (FEW) resources are fundamental drivers of regional development. As regional economies develop and urbanization progresses, sectors with high resource consumption and emissions are relocating to other regions. Consequently, the uneven distribution of resources and irrational regional industrial structure enhance the spatial transfer of resources, which leads to increased environmental pollution and resource wastage due to transportation. This study first employed Multi-regional Input-Output (MRIO) model to trace the FEW flow paths across 30 provinces in China. This study introduced an indicator of resource import-export efficiency, designed to reflect changes in resource efficiency that are influenced by alterations in import-export relationships, rather than by the total mass of resource transfers. The results show that (1) In 2015 and 2017, Henan, Hebei, and Guangdong were prominent interprovincial exporters of food resources in China, primarily supplying to provinces in Eastern China, with Henan significantly influence the national food resources transfer network due to central location. (2) Hebei, Inner Mongolia, and Jiangsu were the primary exporters in China's interprovincial energy trade network, directing significant energy supplies to Eastern and Southwest regions. (3) Xinjiang, Jiangsu, and Heilongjiang were the main contributors to China's interprovincial water exports, predominantly serving regions with high agricultural demand like Guangdong and Eastern China. (4) The import-export dynamics of food and water resources have improved, but the efficiency of energy trade still needs enhancement. Finally, this study presented implications including promoting adjustment of industrial structure, constructing strategic population agglomeration, and improving water efficiency in agricultural sectors.

Paper ID: 226

Citric acid-enhanced activated carbon from plastic waste char for contaminants adsorption in water

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Abstract:
Chemical valorization through pyrolytic thermal processes offers a promising solution by converting waste into three distinct phases: a gaseous phase, a liquid phase known as oil, and a solid carbonaceous residue termed char. Although pyrolysis technology has advanced significantly, the utilization of the solid char fraction remains underdeveloped, impeding the circular economy potential of this process. This study examines the viability of utilizing solid waste from the pyrolysis of post-consumer plastics, sourced from the reject fraction of an urban solid waste facility, as a precursor for activated carbon materials with potential applications in the removal of contaminants from water. Previous investigations with various activating agents have shown that Na2CO3 is the most effective for enhancing the adsorption of lead and acetaminophen in aqueous solutions. To further improve the material's adsorption capabilities, this study focuses on the surface functionalization of the activated carbon by incorporating oxygenated groups through citric acid treatment. The impact of citric acid concentration on the modification process was assessed in terms of textural properties (N2 adsorption-desorption isotherms, CO2 adsorption isotherms) and surface chemistry (X-ray photoelectron spectroscopy, XPS), along with elemental and immediate analysis. The study evaluated its effects on the enhanced adsorption of lead and acetaminophen. Despite a reduction in overall textural porosity, particularly microporosity due to a blocking effect, citric acid modification significantly increased the presence of oxygenated groups, which are crucial for improving the adsorption of heavy metals such as lead.
Furthermore, an economic analysis of the activation and modification processes was performed. The results indicate that surface functionalization with citric acid, although it decreases porosity, effectively enhances the material's performance in contaminant adsorption, offering a viable and cost-effective approach for environmental remediation.

Paper ID: 227

Toward the optimization of hydrogen production using a combined thermal cracking/steam reforming system and Ru-RuO_2 containing catalysts

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Abstract:

A complete analysis of a catalytic pyrolysis process evolved to a combined in-situ thermal cracking-steam reforming scheme to valorize non-recyclable plastic waste is presented. The study aims to analyze the three fractions obtained, focusing on the production of a hydrogen-rich gaseous fraction with industrial interest. The optimization in terms of hydrogen generation is carried out using various ruthenium-containing catalytic systems prepared by a facile preparation method and the resulting composite materials were well-characterized in terms of chemical, electronic, and morphologic properties.

The catalytic systems in which oxide supports (TiO2 and ZSM5) were used favored the formation of smaller RuO2 agglomerates, while the metal-free supports (C and g-C3N4) led to the formation of particles with larger secondary size but dominated by a metallic structure (Ru0) on the surface. No noticeable effect on the structure of the supports was observed due to the deposition of the minority phase, whereas a reduction in the specific superficial area/pore volume and an enhancement of the superficial acidity were observed. Hydrogen production was optimized using Ru/TiO2 composite sample and a reaction scheme including catalytic cracking of the solid plastic waste along with steam reforming of in-situ generated pyrolytic vapors at 550 oC. Under these experimental conditions, the process allows the production of 270.7 mmol of hydrogen (13.5 mmol/g of plastic waste), which overperform by an enhancement factor of 6.3 the steam- and catalyst-free pyrolytic reference (43.1 mmol). The best catalytic response appears to be associated with the combination of several parameters. Medium- and high-strength acid sites, promoted by the existence of smaller RuO2 particles (2-5 nm) deposited on a TiO2 structure with an advantageous pore distribution, are the main properties that optimize hydrogen generation.

Paper ID: 229

Global land carbon storage loss driven by mining critical metals for energy transition

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Abstract:
Mining activities for energy transition critical metals lead to the destruction of vegetation and soil in the mining areas, resulting in the loss of local land carbon storage. There is a lack of large-scale quantitative research on global land carbon storage loss in mining areas for critical metals, leading to an overestimation of the lifecycle emission reduction potential of renewable energy systems. This study aims to identify the global land carbon storage loss caused by the mining of critical metals for energy transition (focusing on lithium, cobalt, nickel, and platinum) by integrating a bottom-up constructed global land use database for critical metal mining area polygons with the SoilGrids global surface 30 cm soil organic carbon density map and the global aboveground and belowground biomass carbon density maps for the year 2010. The study found that the global land carbon storage losses for lithium, cobalt, nickel, and platinum mining areas were 2.3×107 t C, 5.4×107 t C, 6.6×107 t C, and 5.8×107 t C, respectively, totaling 2.0×108 t C, equivalent to 6% of China's total CO2 emissions in 2022. The three ecoregions with the highest land carbon storage losses were Central Zambezian Miombo woodlands, Sulawesi lowland rain forests and Highveld grasslands. The carbon storage losses of the four metals were concentrated in the US, Australia, DRC, Indonesia, South Africa, China, Russia, and Canada. Sixty percent of the carbon storage losses occurred in developing countries, where the carbon storage loss per unit area was higher than in developed countries. In typical critical metal mining countries like Indonesia, carbon emissions from land use change in nickel mining areas were equivalent to 39% of carbon emissions resulting from energy consumption. This study shows that the carbon storage loss due to land use changes in critical metals mining areas is substantial and cannot be ignored.

Paper ID: 230

Life cycle carbon emissions of sewage sludge and food waste treatment in China

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Abstract:
Urban organic waste management significantly influences urban carbon emissions, primarily driven by sewage sludge and food waste. Emphasizing their low-carbon utilization is crucial. This study aims to comprehensively analyze the treatment of sewage sludge and food waste in China, and forecast carbon emissions by combining the life cycle perspective and the Intergovernmental Panel on Climate Change (IPCC). The treatment technologies evaluated included a novel anaerobic co-digestion of sewage sludge with food waste and alternatives including landfill, incineration, aerobic composting, and anaerobic digestion. The analysis quantified their carbon emissions and identified key influencing factors. Under assumed future scenarios, the study predicted carbon emissions from sewage sludge and food waste treatment in China by 2050. In the conservative scenario, carbon emissions are anticipated to peak at 84 million tons CO2-eq in 2030. Compared to this, the optimistic scenario using anaerobic co-digestion technology shows a significant reduction in carbon emissions. Specifically, cumulative emissions could decrease by approximately 655 million tons CO2-eq from 2020 to 2050. Accelerating the transition of sewage sludge and food waste treatment from landfill to incineration or biological treatment is essential. China should further implement waste classification policies and expand anaerobic digestion facilities,so that more sewage sludge and food waste would enter anaerobic co-digestion, which is pivotal for achieving carbon neutrality in the waste management sector.

Paper ID: 231

Fabrication of Z-scheme Fe2O3/ZnS/CNTs nanohybrid for efficient photoelectrochemical and enhancing degradation of sulfamethoxazole Pollutants: Mechanism and degradation pathways

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Abstract:
In this present study, Fe2O3/ZnS/CNTs (FZC) nanohybrid were combined to create ternary nanocomposites for water treatment via photoelectrochemical and photocatalysis. The synthesis of carbon nanotubes (CNTs) assisted in the pyrolysis method. Fe2O3 and ZnS nanoparticles were effectively anchored in CNT surfaces. According to morphology and structural analysis of a prepared sample using XRD, SEM, HR-TEM, XPS, PL, FTIR, UV-vis DRS. The nanocomposite was investigated for photocatalytic degradation of Sulfamethoxazole (SMX) under visible light irradiation. The Fe2O3/ZnS/CNTs nanohybrid photocatalyst shows an excellent degradation response in SMX pollutants by degrading them up to 98.3%, and the optimal transient photocurrent density (0.39 μA/cm2) with visible light irradiation. The unique microstructure and band alignment of Fe2O3/ZnS/CNTs nanohybrid could be attributed to the significantly improved photoelectrochemical (PEC) and catalytic activities. The efficient Z-scheme heterojunction catalyst by the introduction of CNTs efficiently photo-electron acceptor much promoted the photogenerated charge transfer.

Paper ID: 233

Material flow analysis, life-cycle assessment, and net cost analysis help determine environmental and economic benefits of zero-waste strategy of industrial park

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Abstract:
Accelerating industrialization has increased resource exploitation, sharply raising solid waste production. The Sustainable Development Goals (SDGs) aim to significantly reduce waste through responsible consumption and production by 2030. However, managing waste is challenging due to its size, growth, variety, prevalence, and wide-ranging impacts. This research develops a framework combining material flow analysis, life-cycle assessment, and net cost analysis to evaluate the environmental and economic benefits of a zero-waste strategy in industrial parks. The framework comprises six steps: determining the goal, establishing waste flow analysis, choosing scope, investigating data, discerning environmental and economic performance, and evaluating results with decision support. Nested inner loops track improvements and emission control measures, dynamically assessing the synergistic reduction of pollutants and cost-effectiveness in solid waste management. Material flow analysis characterizes the waste flow of the industrial park, identifying key waste generators, wastes types and fate, forming the basis for setting the scope and boundaries. Integrated life-cycle assessment and net cost analysis provide a comprehensive understanding of environmental and economic performance. Examining the entire waste management process—from generation to disposal—guides decisions to identify opportunities for resource substitution and reuse. A case study investigates a typical industrial park that collaborates with a cement kiln to manage hazardous waste through industrial symbiosis, evaluating the environmental and cost effectiveness of a zero-waste strategy. The cement kiln, as the primary disposal method, works as a fundamental facility to solve the hazardous waste problems. Compared to non-symbiotic scenarios, the symbiosis pattern of industrial park and cement kiln reduces 1.48 tonnes of CO2e emissions and achieves a cost benefit of 133 CNY when treating one tonne of hazardous waste. The case study demonstrates the feasibility and operability of the evaluation framework.

Paper ID: 234

Is multi-source solid waste co-disposal practices in waste-to-energy plants sustainable？A comparative life cycle assessment

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Abstract:

Co-disposing of combustible multi-source solid waste using excess waste-to-energy capacity represents a widely adopted symbiotic waste treatment model. However, this model's sustainability and applicability remain uncertain, particularly regarding whether additional pollution and resource waste exists compared to traditional individual disposal technologies. This study conducted a comprehensive life cycle assessment of four typical waste co-disposal technologies (food waste, municipal sludge, medical waste, and industrial waste) for sustainable waste management, quantifying waste and energy metabolism processes, evaluating multidimensional energy, environmental, and economic indicators, and comparing them with ten individual disposal technologies. The results show that all co-disposal technologies achieve over 95% reduction efficiency, with fly ash as the only residue requiring landfilling, and energy recovery efficiency ranging from 27.6% to 63.3%. Food waste co-disposal shows environmental benefits across all indicators, while municipal sludge shows adverse impacts. Medical waste and industrial waste reduce other environmental impacts but cause 231.3 and 201.1 kg fossil carbon dioxide emissions per ton, respectively. All co-disposal projects demonstrate substantial economic benefits, with IRRs ranging from 16.8% to over 2000%. Co-disposal technologies are economically superior to individual disposal methods, expected to reduce waste disposal fees by 23.7% to 90.5%. Despite these benefits, co-disposal technologies do not excel optimal across all energy and environmental indicators. Food waste and municipal sludge co-disposal are less energy-efficient than anaerobic digestion technologies, while industrial waste co-disposal is more carbon-intensive than landfilling. This study recommends using co-disposal as a supplementary approach rather than a primary solution. Finally, it highlights the need for clearer industry standards and national guidelines, the development of regional strategies, and improvements in operational and regulatory frameworks to enhance the sustainability and applicability of co-disposal technologies.

Paper ID: 235

Economic and environmental assessment of plant-level decarbonization in waste-to-energy industry with CCUS technology: Evidence from China

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Abstract:
Waste-to-energy (WtE) technology is a key method for municipal waste treatment, particularly in China, the largest country by waste incineration volume globally. However, the increasing proportion of high-carbon waste components has led to a rise in the carbon intensity of WtE generation. This trend presents significant challenges for the low-carbon development of WtE plants. Carbon capture, utilization, and storage (CCUS) offers a potential technical solution for deep decarbonization of WtE facilities. Nonetheless, the associated economic costs and environmental impacts, such as water consumption, remain uncertain. In response to these challenges, a plant-level carbon source inventory for the WtE industry in China was established to evaluate the temporal and spatial emission characteristics, and the CO2 emission reduction potential, CO2 abatement cost, and water demand were analyzed by developing a CCUS source-sink matching optimization model and a techno-economic evaluation model. The findings indicated that the total CO2 emissions from China's WtE plants amount to approximately 318.50 Mt annually, with emissions predominantly concentrated in the eastern and coastal provinces in China. A total of 996 WtE plants could be matched with suitable CO2 storage sites within 800 km, potentially achieving a theoretical total emission reduction of up to 6.86 billion tons of CO2. Among these, 147 WtE plants can reduce over 2.4 billion tons of CO2 with an average cost of 91.1 CNY/t. However, the carbon-water trade-off issue may become significant for the WtE industry during the decarbonization process using CCUS technology. This study evaluated the economic and environmental impacts of deploying CCUS technology in the WtE industry in China, offering valuable insights for government and relevant enterprises. Additionally, it may serve as a reference for other countries considering the application of CCUS technology in WtE industry.

Paper ID: 236

You shall not pass: how to collaborate with startups or incumbents for overcoming barriers to sustainable innovation in the textile industry

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Abstract:
Collaborative innovation is essential for addressing grand challenges like climate change, yet these efforts often face significant barriers. This study investigates the mechanisms and strategies of collaboration for sustainable innovation by providing an overall understanding of such contexts integrating barriers, the role of intermediaries in dyadic collaborations and knowledge spillovers. Using an embedded case study of sustainable innovation projects carried out by a large Italian textile company and its various partners, the research identifies some key factors influencing the success or failure of collaborative projects aimed at sustainable innovation. The findings highlight the critical role of intermediaries in facilitating communication, aligning goals, and providing necessary resources and knowledge. Even failed collaborations can produce valuable knowledge spillovers, fostering future innovation. The study proposes that the timing of barriers and the involvement of additional partners significantly affect outcomes. By examining nine collaborative projects, the research offers insights into effective coordination mechanisms and the importance of trust, strategic alignment, and continuous learning. These findings can also provide practical guidance for managing collaborative efforts in sustainable innovation, emphasizing the need for robust intermediary roles to navigate complex innovation ecosystems.

Paper ID: 237

Is plastic ban a clear solution? A comparative Eco-efficiency analysis of cup usage scenario in Hong Kong

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Abstract:
Single-use plastic (SUP) significantly contributes to global municipal solid waste (MSW). To mitigate the environmental threats posed by SUP, many countries and regions have implemented strict regulations on plastic usage and are promoting sustainable alternatives like plant-based tableware. However, a critical limitation is that existing studies typically focus on either the environmental or economic impacts of these alternatives, but not both simultaneously. This limits their utility for decision-makers and the public in choosing sustainable tableware options and finding a balance between environmental and economic impacts. This study employed an Eco-Efficiency Analysis (EEA) integrating life-cycle assessment (LCA) and economic analysis to evaluate various single-use cups and disposal methods. Ten scenarios were analyzed under the context of strict plastic bans in Hong Kong. Results indicated that bagasse cups treated by composting emerged as the most eco-efficient option, followed by incineration. Paper cups were the second-best choice, while PLA cups ranked the least eco-efficient due to their resource-intensive manufacturing. The plastic ban significantly cuts life cycle costs by 42.89% and greatly improves environmental performance. Combining the plastic ban with improved waste management achieved the best results, reducing life cycle costs by 40.29% and enhancing environmental performance by 52.41%. These findings offer actionable insights for policy decisions to foster sustainable practices in urban settings like Hong Kong.

Paper ID: 238

How far can circular economy practices contribute to a carbon-neutral Europe? The case of flat glass production in the construction sector

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Abstract:

The construction sector heavily relies on non-renewable resources for energy and materials. Addressing this, Circular Economy (CE) is frequently suggested as a means to foster sustainable growth while reducing global emissions. Yet, the actual impact of CE in the long term is still uncertain due to limited empirical evidence and various factors that may hinder its widespread adoption. Indeed, the transition to CE might necessitate a substantial transformation in production capabilities, supply chain modifications, the phasing out of existing capital, and investment in new technologies and facilities. This study introduces for the first time a JRC-TIMES-based methodology to assess the significance of feedback loops in construction, focusing specifically on flat glass production, a notably carbon-intensive component of the industry. JRC-TIMES model is an optimization model that integrates the processes of energy consumption and production for European countries to suggest the most cost-efficient options for mitigation of greenhouse gases emission. We have enhanced the model by incorporating conventional flat glass processes and have specifically designed closed-loop value chains to evaluate the impact of circular economy practices on the business-as-usual scenario. Through this approach, we can assess the contributions of each circular economy practice in various CE implementation scenarios, focusing on energy, emissions, and material savings. Results can provide a more precise measurement of the circular economy's role in climate mitigation and offer Policymakers quantitative insights into the effectiveness of circular economy strategies to overcome market and technical challenges.

Paper ID: 242

Decommissioning of coal-fired power plants constrains the cement industry's decarbonization pathway

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Abstract:
Mitigation solutions for high-carbon industrial infrastructures to address climate change are often developed in isolation to achieve optimal technical, economic, and environmental scenarios. Such single-sector decarbonization scenarios may harm industries that coexist with them, thereby reducing decarbonization opportunities. We focus on fly ash, where the availability of fly ash declines significantly after power plant retirement, and examine decarbonization opportunities and risks in the cement industry through industrial symbiosis at the infrastructure scale through fly ash recovery. We seek to answer four questions. First, the current decarbonization potential and symbiotic benefits of alternative clinker pathways in the cement industry, including reductions in carbon and air pollutants in the cement industry and avoided mercury migration from power plants. Second, the loss of benefits and impacts on the resilience of symbiotic networks due to power plant retirement. Third, the costs of alternative decarbonization pathways in the cement industry and the inequality risks that come with rising costs. Since cement prices account for a large difference in the share of urban and rural construction costs, price increases will preferentially hit rural populations who are relatively unable to afford it. Fourth, the optimal pathway for power plant retirement and cement plant decarbonization, with the remaining power plants still providing the solid waste needed by the cement industry. Our study highlights the importance of integrated industrial symbiotic system solutions for more resilient, feasible, opportunity-rich, and cost-effective decarbonization.

Paper ID: 244

Evaluating the semiconductor supply chain impact on carbon neutrality in the AI Era: a hybrid approach

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Abstract:
As the global community targets 2050 for achieving carbon neutrality, the rapid advancement of artificial intelligence (AI) accelerates the significant increase in energy and resource consumption attributed to semiconductor manufacturing—a major source of carbon emissions from electronic products and server equipment which presents a dilemma for balancing carbon neutrality objectives against technological development. To address this issue, this study collected statistical data on energy consumption and carbon emissions from major listed companies across six segments of the semiconductor supply chain (SSC) in China, and proposed a hybrid approach that integrates Decision-Making Trial and Evaluation Laboratory (DEMATEL), machine learning and Monte Carlo simulation method to identify the key factors and interrelationships between AI technological progression and SSC key factors from the perspective of carbon neutrality. The findings aim to assist governments and enterprises in realizing how AI-driven semiconductor manufacturing can influence carbon neutrality goals, facilitating informed policy and resource allocation. The contributions of the study are as follows: (1) strengthening the AI-driven SSC understanding by bridging the carbon neutrality with SSC; (2) proposing a hybrid method for analyzing the compound interrelationships among semiconductor supply chains; and (3) providing a visual and data-driven analysis to reveal the AI-driven SSC influence on carbon neutrality.

Paper ID: 245

Bridging artificial intelligence and the circular supply chain achieves the socio-technical synergy for the fast fashion industry: An integrative influential model

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Abstract:
Previous studies have emphasized bridging the concept between disruptive technologies and circular supply chain, which can achieve socio-technical synergy for the fast fashion industry, the emergence of artificial intelligence can accelerate the efficiency of resource use and reduce the generation of waste and emissions. Although these studies have attempted to develop models to guide practice, these models still neglect the focus on the artificial intelligence and use a single type of data without considering the stakeholders and different types of data. Accordingly, this study aims to develop an integrative influence model by using a hybrid method to integrate text mining, exploratory factor analysis, reliability testing, Google Trends, Baidu Index, fuzzy synthetic method, as well as decision trial and evaluation laboratory method, which can consider the relative stakeholders by merging different representative data. The contributions of the study are as follows: (1) strengthening its theoretical basis, promoting this understanding by bridging artificial intelligence and the circular supply chain achieves the socio-technical synergy; (2) proposing a hybrid method for overcoming the dilemma fast fashion industry; and (3) providing a visual and data-driven analysis that offers a precise direction for making improvements with artificial intelligence toward the circular supply chain. Keywords: artificial intelligence; Circular Supply Chain; Socio-Technical Synergy; Influential Model; Fast Fashion

Paper ID: 246

Effective utilization of oyster industrial wastes for aquaponics system as source of alkalinity and minerals

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Abstract:
Oyster shells are one of the main local industrial wastes in Hiroshima, Japan. In general, most of it has been processed into fertilizer and animal feed. On the other hand, oyster shells have high potential as an auxiliary material for aquaculture due to its high content of calcium carbonate, phosphorus and minerals. In this study, oyster shells were used as a source of alkalinity and minerals in the aquaponics system to achieve sustainable waste treatment with food production. The aquaponics system consisted of an aquaculture tank, two trickling filters and two hydroponic beds. The trickling filters were filled with polyurethane sponge and oyster shells as microbial carriers and auxiliary material, respectively. Oreochromic niloticus was cultivated in the aquaculture tank. Solanum lycopercisum and Capsicum annuum were grown in the hydroponic beds. During the continuous experiment, the trickling filters maintained high nitrification performance without accumulation of ammonia and nitrite. In the aquaculuture tank, the pH was strongly influenced by the feeding rate and the amount of oyster shells. In order to optimize the amount of oyster shells, nitrogen-oyster shells loading rate (N-OS load, kgN/(kgOS.d)) was proposed as a new parameter for the aquaponics system. With a N-OS load of less than 1.0, the pH in the aquaculture tank was maintained at around 6.5. In addition, the concentrations of nitrate, phosphate and calcium increased. These results indicated that the oyster shells dissolved and provided alkalinity and nutrients in the aquaponic system. However, some minerals still became rate-limiting nutrients for plant growth in the hydroponic beds. As a result of microbial community analysis, nitrifying bacteria of the genus Nitrospira were detected from both the sponge carrier and the oyster shells. Therefore, the oyster shells acted not only as a source of alkalinity and minerals, but also as a microbial carrier in the aquaponics system.

Paper ID: 247

Life cycle assessment of cultivated unagi

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Abstract:
Cellular agriculture (i.e. cultivated meat) is a potentially promising demand-side technology that could help reduce the adverse impacts of animal-based products. In addition to less animal cruelty, recent LCAs point to the potential reduction in GHG emissions that would be achieved if cultivated meat displaces conventional meat production and consumption. Yet while a growing number of LCA studies examine lab-based alternatives to 'farm animals' including cattle, lamb, or chicken, studies on cultivated seafood are surprisingly lacking. Furthermore, the potential of cultivated meat to alleviate other critical environmental burdens such biodiversity loss is understudied despite cultural and global significance. For example, the Japanese freshwater eel, also called Unagi, is an endangered species which plays an essential part of the Japanese food culture. Japan is the biggest consumer and producer of Unagi. Although Unagi population has declined by as much as 90% over the past 30 years and is considered an endangered species with a key role in aquatic ecosystems, the demand for Unagi is growing driving the selling price up; Breaking any price barriers for alternative products such as the cultivated eel. Using LCA we evaluate the cradle-to-gate environmental impacts associated with the production of cultivated eel- a hybrid product containing a mixture of plant-based proteins and cultivated Unagi organoids, and compare its environmental impacts to conventional eel farming. In addition, we use different production scenarios to assess how assumptions and modeling choices regarding raw material inputs, waste processes, and the use of different datasets affect results. To the best of our knowledge, this work presents one of the first LCA of cultivated seafood or fish and thus adds to the emerging body of work on the environmental impacts of cellular agriculture.

Paper ID: 249

A substocks-driven model for examining key factors determining carbon reduction in the new technology penetration process

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Abstract:
Human activities, principally through emissions of carbon dioxide, have caused global surface temperature reaching 1.1°C above 1900 in 2020. Consequently, there is an urgent need to implement effective strategies aimed at mitigating carbon emissions. The promotion of technology upgrading, such as electrification, has been proven to be a measure in reducing carbon emissions. However, the promotion of new technologies often coincides with the phase-out of old ones. While previous studies have primarily focused on examining the environmental impacts of single-product upgrades, a research gap remains regarding the dynamic process of new technologies penetration in replacing old ones. More attention should be directed towards modeling the new technology penetration process. The traditional stock-driven model treats the lifetime of product as an intrinsic parameter. However, it cannot address the shortened lifetime problem driven by the increasing penetration rate of the new technology. Therefore, this study constructed a comprehensive substocks-driven model that includes both the new and the old technology stocks to identify the key factors influencing the carbon reduction in process of new technology penetration and old technology phase-out. We integrated the dynamic material flow analysis (dMFA) and modular life cycle assessment (mLCA) methods to incorporate multiple new technology pathways and technological characteristics. The dMFA will provide a framework for modeling the inflow and outflow of products, while the mLCA will enhance this framework by integrating carbon emission information. The results indicate that the increase or decrease in stock and the proportion of carbon emissions at different life cycle stages will affect the sensitivity of carbon reduction potential. With the acceleration of the penetration rate of new technology, the carbon reduction is more sensitive to the carbon emissions during the production phase. Rapid penetration of the new product will result in inversely proportional decrease in the service life of the old product.

Paper ID: 251

E-waste in Indonesia: an overview on generation and collection, policies, recycling practices, challenges and current trend

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Abstract:

While electronic waste (e-waste) has been extensively discussed worldwide, it remains a grey issue in Indonesia. This study presents the current status of e-waste in Indonesia. Firstly, this study presents statistics on e-waste generation. In 2023, the total e-waste generation amounted to almost 2.2 million tons, averaging 7.6 kg per capita. The potential economic value of this e-waste, if all recoverable metals were fully recovered, is estimated at about $1.4 billion. Indonesia, e-waste is classified as B3 waste, which refers to materials containing hazardous and toxic substances. Therefore, the management and treatment of e-waste adhere to the rule on waste reduction and reuse, with less emphasis on recycling for recovering economic value. Indonesia has a significantly low level of e-waste collection and infrastructure availability, with only 5% of the total e-waste generated being collected. Another concern being emphasized is the unequal distribution of e-waste generation in Indonesia due to geo-economic factors. As in other developing countries, informal recyclers play a predominant role in e-waste management, which often employing improper recycling techniques. Despite these challenges, the study identifies positive trends, such as increasing research and development (R&D) to effectively manage e-waste. This includes efforts to optimize the economic benefits of e-waste through metal recycling. This is mostly driven by local start-ups, universities, and research institutions. The findings of this study are crucial for guiding future strategies in e-waste management in Indonesia, specifically in order to achieve the same level of proficiency as developed countries.

Paper ID: 252

Evaluation of PAHs in diverse recycled plastics

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Abstract:

Increased recycling of plastics towards a circular economy requires attention due to the possible presence of contaminants in recycled plastics and the risk it poses to human health and the environment according to the Regulation (UE) 2022/1616. The relationship between the formation of the 16-priority polycyclic aromatic hydrocarbons (PAHs) and various factors such as the origin and processing of the recycled plastics will be determined. Noteworthy, the present study is the first to address the comparison regarding PAH content in different types of recycled plastics since no information about this comparison is available in the literature. A total of 25 samples were analysed. The analysis in this study encompassed a diverse selection of polymers, including samples of LDPE, HDPE, PP, PET and different mixtures: PE/PET, PP/PE/EPDM and PP/EPDM. These polymers were obtained from various recycling companies around the world, most of them being post-consumer plastics. The PAHs were extracted by stirring for 24 hours at room temperature using a mixture of acetone and dichloromethane (1:1 by volume). To remove impurities and dissolved plastic from the extraction, the samples were cleaned-up and then eluted with C18 SPE cartridges. The analysis of PAHs was performed via high-performance gas chromatography with mass spectrometry (HRGC-MS). The samples with the lowest total PAHs concentration were PET samples, most of them being non-detected. In contrast, a black LDPE sample provided the highest total PAHs concentration of 2200 ng/g. This sample had the highest toxicity, reaching a value of 68 ng TEQ /g, while the least toxic sample was PET, which had a toxicity of 0.071 ng TEQ /g. The results show the importance of monitoring the presence of these pollutants in samples of recycled plastics and additives, as they may be a source of unwanted toxic pollutants.

Paper ID: 255

Global productivity-weighted agricultural land use driven by human consumption

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Abstract:

Global agricultural land occupies almost half of all habitable land, increasing over time with many environmental impacts. Increasing land use efficiency can both reduce these impacts and limit land expansion. Here we examine trends in productivity-weighted land over time, that is, the ability of land to yield high agricultural outputs. We define productivity-weighted agricultural land use as the ratio of agricultural output to country-specific and product-specific yields. We estimate the productivity-weighted land use driven by different food consumption from 1986 to 2020. Using a physical flow model, tracing food in international trade, we find that productivity-weighted cropland for primary crops increased 26.6% (from 1140 Mha to 1444 Mha), primary crops used for feed increased 21.4% (from 341 Mha to 414 Mha). We use new methods for estimating productivity-weighted pastureland and find an increase of 46.9% (from 1226.5 Mha to 1801.3 Mha), while productivity-weighted land used for fodder decreased by 27.8% - broadly similar to the increase in feed, indicating a swap from fodder to feed as production systems intensified. Per-capita productivity-weighted cropland decreased from 0.23 ha to 0.18 ha, while per-capita productivity-weighted pasture decreased from 0.25 ha to 0.23 ha. We find evidence that the decrease in per capita productivity-weighted land use has plateaued in recent years. Animal products comprised 74.0% of the total agricultural productivity-weighted land expansion, equivalent to an area the size of EU27+Greenland, while plant-based products accounted for 22.4%, equivalent to an area the size of Mexico. Although per-capita productivity-weighted land use has reduced it has been insufficient to peak agricultural land, with implications for deforestation, natural carbon solutions, and biodiversity protection.

Paper ID: 259

Evaluating recycling efficacy: a statistical entropy analysis of mattress disposal methods

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Abstract:

Waste generation and management present a pressing challenge, emphasizing the need for a circular economy. Decision makers, relying on product-specific, process-based, and technology-specific assessments such as life cycle assessment (LCA), face significant limitations in evaluating products with emerging technologies or alternative waste management systems. LCA may introduce biases by emphasizing existing waste management systems, hindering adaptability to evolving practices. Recent advancements in using entropy for sustainability analysis, specifically Multilevel Statistical Entropy Analysis (MSEA), provide a more robust and complementary ex-ante evaluation, particularly relevant for waste management. In a circular economy, maintaining entropy at an optimal level is crucial for effective resource management and supporting resource recovery. MSEA, based on Shannon's information theory, quantifies the distribution of variables, measuring their concentration or spread. High entropy indicates uniform distribution, while low entropy indicates concentrated distribution. We hypothesize that combining MSEA on both product complexity and geospatial spread levels can yield a sustainability parameter that aids in developing efficient recycling initiatives. In doing so, the effectiveness of the recycling process can be gauged in terms of entropy change per energy unit, and against CAPEX and OPEX costs. Once geospatial spread is added, we can compare the full cost of separation to its associated entropy reduction. In this work, we introduce mattresses as a case study due to their significant disposal challenges. The recycling methodologies examined are incineration, landfilling, and mechanical recycling. Results indicate that mechanical recycling is the only method that reduces entropy, thus purifying the waste stream. Landfilling maintains the entropy level, as waste is merely dumped, while incineration increases entropy, producing gases and ashes. Mechanical recycling emerges as the most effective method from an entropy perspective, supporting its potential in advancing sustainable waste management practices. Research on the effectiveness of chemical recycling in terms of entropy reduction is currently underway.

Paper ID: 261

Application and scenario simulation of multimodal GPT in circular economy transition: a case study of Taiwan's material flow data

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Abstract:

The application of multimodal Generative Pre-trained Transformer (GPT) models in circular economy transition research is still insufficient. The latest multimodal GPT can recognize various types of circular economy system diagrams, such as causal loop diagrams or stock and flow diagrams, and convert them into corresponding software programs. By providing interactive text descriptions related to these diagrams, multimodal GPT can link the dynamic relationships of software objects, such as the relationship between resource consumption and pollutant emissions, and the decisions and impacts of stakeholders. With adequate contextual descriptions, we can obtain realistic system models. Additionally, GPT models can help visualize the results of system model operations, quickly providing necessary problem perspectives and observation angles, such as layered analysis through stratification diagrams or identifying the vital few through Pareto charts. After achieving satisfactory basic results in system modeling, we can use GPT models for scenario simulation, quickly generating and testing reasonable parameter combinations to determine optimal solutions and corresponding measures, providing decision-making references for national policies or corporate strategies. We use Taiwan's material flow data and policy acts from 2013 to 2022 as a case study to verify the aforementioned methodology. We hope that multimodal GPT can accelerate the circular economy transition, identify key obstacles earlier, and provide innovative solutions.

Paper ID: 262

Spatial dispersion of road eco-environmental impacts: A fishbone theory

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Abstract:
The impact range of roads and associated transportation activities on various ecological processes forms the Road Effect Zone (REZ), which often spans significantly larger areas than the roads themselves. These activities can induce land use changes and increase pollutant concentrations in adjacent areas. However, there is a paucity of fine-scale maps detailing ecological changes within REZs, impeding precise spatial quantification of road impacts on the environment. This study introduces a novel Road Influence Index (RII) to address this gap. Utilizing Shanghai-Nyalam Road (National Highway 318) as a case study, the research investigates the spatiotemporal dynamics of forest cover within the REZ and identifies the driving factors influencing these changes. The results indicate that between 2000 and 2019, the forest loss rates in the eastern, central, and western regions within REZ were 3.62%, 0.68%, and 0.21%, respectively. Highly economic development in the eastern region was the primary cause of forest loss, with the REZ extending approximately 2.50-3.50 km. In the central and western regions, areas with stable annual temperatures were prioritized for urban development, influencing forest cover within REZs of 2.50-3.00 km and 1.50-3.00 km, respectively. The impact of human activities on forest loss decreases from east to west, correlating with economic development intensity. In the forest-scarce western region, high-quality forest resources are primary targets for deforestation, and severe forest loss is observed near provincial borders, likely due to inadequate regulation.

Paper ID: 263

Study on catalytic conversion of biomass based on single atom catalyst

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Abstract:
Low-carbon circular economy has become a global consensus, and bio-based industry is an important part of it. Compared with traditional petrochemical products, bio-based products converted from renewable biomass have important advantages in carbon reduction. Based on this, research in biomass conversion based on new catalytic systems with continuous heterogeneous catalysis, nanocatalysis and super-hydrophobic surface catalytic reactions has been developed: 1. Design and prepare single atom metal catalysts of phosphorous coordination with high specific surface area, high catalytic activity and high cycle life. Realize the conversion and modification application of renewable biomass (such as glycerin, furfural, glucose,etc.) under mild conditions. 2. According to the characteristics of the reaction system and the discharge of acid and alkali waste liquid in industry, a green synthesis route is developed by combining heterogeneous catalysis and membrane treatment technology.

Paper ID: 264

The impediment of CBAM on global steel product trade incurs welfare losses

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Abstract:
The EU Carbon Border Adjustment Mechanism (CBAM) has been proposed to charge for the embedded CO2 emissions in imported products to mitigate climate change. However, the impact of CBAM at the product level is rarely quantified. By integrating a bottom-up CBAM cost accounting model and an economic simulation model, we calculate the CBAM equivalent carbon tariffs for 198 steel products and simulate its impeding effect on global steel trade and national economic welfare. We find that EU-dependent exporters are more vulnerable to CBAM, with Russia facing the highest tariff of 43.1% on sintered ore. The implementation of CBAM hinders the steel product trade and significantly reduces exports to the EU, particularly noting a 35.4% decrease in pig iron. Further analysis reveals that CBAM damages global welfare, diminishing the EU's producer and consumer surplus by $5.2 billion. This study highlights the critical need for globally coordinated trade policies and recommends CBAM-responsive initiatives for vulnerable countries to facilitate global trade and reduce welfare losses.

Paper ID: 265

Evaluating recycling channels for retired electric vehicle batteries: A framework for enhancing circularity and sustainability

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Abstract:
As the adoption of electric vehicles accelerates and critical materials become scarcer, the sustainable management of retired electric vehicle batteries (REVBs) is increasingly vital. Current literature often exhibits a biased conceptualisation of circularity and neglects the importance of integrating closed-loop and open-loop supply chains. This oversight hampers the optimal allocation of REVBs among recycling channels, crucial for maximising outcomes in both the circular economy and sustainability. This study proposes a comprehensive set of evaluation criteria for ranking recycling channels, including preserving REVBs functions, upgrading REVBs, repurposing REVBs, recycling REVBs materials, and recovering energy. It also develops a REVBs channel selection matrix at the supply chain level. A novel hybrid method is introduced, combining the Pythagorean Fuzzy Analytic Hierarchy Process with the Pythagorean Fuzzy Dynamic Measurement Alternative and Ranking according to Compromise Solution. This approach is applied across three recycling scenarios: low, standard, and high. Data from 15 panel experts indicates that 'value' and 'efficiency' are crucial for circularity, while the 'environment' dimension is most significant for sustainability. Results consistently show that repurposing REVBs components ranks highest in both circularity and sustainability across all scenarios. Recycling REVBs materials performs particularly well in high and standard recycling scenarios, suggesting its effectiveness in more intensive recycling processes. Conversely, recovering energy generally ranks lower in both metrics across all scenarios. This research emphasises the need to conceptualise circularity across five dimensions: material and energy, waste and pollution, efficiency, longevity, and value. It advocates for the redesign of existing REVBs supply chains, emphasising repurposing and reusing REVBs. By providing a robust and dynamic evaluation of REVBs recycling channels, the study offers companies and policymakers a critical basis for decision-making, enabling them to excel in both circularity and sustainability.

Paper ID: 266

Data-driven approaches promotes sustainable industry-city development

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Abstract:
The environmental pollution derived by industrial emissions poses far-reaching challenges on sustainable cities, livable communities, and public health, especially in urban areas with industrial clusters. Environmental complaint is an effective handle for bridging industrial behaviors and public responses to reach sustainable industrial systems. However, the underlying mechanisms and driving factors of environmental complaints on industrial enterprises are diverse and interactive, which makes it difficult for local environmental managers to effectively supervise and take measures. Here, we proposed a data-driven and evidence-based model framework to early predict and proactively respond, and applied it to a real-world case of air pollution of rubber manufacturing. Combing long-term observed complaints data with manufacturing-meteorology-environment data, we trained machine-learning model to predict occurrence of environmental complaint with an average AUC-ROC of 0.79. Process emission behaviors, local wind direction, and historical high-risk period were revealed as the crucial driving factors by utilizing interpretable SHAP values. This suggests that the management of environmental complaints needs to take into account pollution sources, external environment, and resident status. Furthermore, giving the flexibility of the enterprise's production schedule, we employed adaptive genetic algorithm to minimize long-term environmental complaint risks defined by output of prediction model. Our study demonstrates the potential of data-driven approaches in effective and proactive managing environmental complaint risks, while avoiding adverse effects on industrial systems caused by the tri-stakeholder stalemate between managers, enterprises and communities, thereby promoting sustainable industry-city development.

Paper ID: 267

Thermodynamic simulation of WPCBs-smelting: effect of feed composition and smelting condition

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Abstract:

Waste printed circuit boards (WPCBs) have become one of the most important electronic waste (e-waste) components due to their high concentrations of valuable metals, particularly copper. Smelting has emerged as a major approach for recovering valuable metals from WPCBs due to its ability to process different types of WPCBs, recover energy from polymers in WPCBs, and achieve high productivity. More importantly, the smelting of WPCBs can be integrated into existing commercial smelting facilities (referred to as black copper smelting). Given the variety of metals present in WPCBs, it is crucial to have a comprehensive understanding of the metal behavior during the smelting process. This study simulated the thermodynamic characteristics of outputs during the smelting stage of WPCBs within the secondary copper smelting process. Simulations were conducted by combining WPCBs and copper scrap, with different mass ratios, as input materials. The effect of several parameters was investigated, including temperature (900–1500°C), oxygen partial pressure (pO2, 10–11–10–6 atm), and WPCBs to mass ratio (25%–75%). The thermodynamic simulation predicted the optimum conditions of 1300°C, pO2 10–9 atm, and 50% WPCBs mass ratio as the feed, resulting in black copper containing 79.9% copper with copper loss into slag of 0.70%. The study also discussed the distribution of other metals, including precious metals (gold and silver), in both black copper and slag, under these optimum conditions.

Paper ID: 268

Predicting recycling potential of solar photovoltaic panel waste: a case study in Jing-Jin-Ji region of China

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Abstract:

The growing installed photovoltaic (PV) capacity and the following sharp rising PV panel waste present resource shortage and environmental pollution risks. Recycling PV panel waste is essential to deal with the serious challenge. Predicting the recycling potential of PV panel waste is the premise for recycling the waste efficiently. Taking Jing-Jin-Ji region of China as an example, by using BP neural network model, market supply A model with Weibull function, and the material coefficient and market value methods, and based on earlier-loss and regular-loss scenarios, this paper reveals the dynamic change rules of PV panel waste volume and the dynamic relationship between the raw materials demand required for PV panel production and the regenerated resources supply from the recycling; and predicts the recycling potential of the PV panel waste from a resource- economic-environmental benefits perspective. The results (regular-loss scenario) show that the PV panel waste volume will be continuously growing and reach its peak in around 2063. From 2025 to 2060, the cumulative regenerated resources from the recycling (c-Si, a-Si, CdTe, CIGS) will reach to about 18.93 million tonnes, among which include 4.08 million tonnes of critical metals and 6600 tonnes of the hazardous metals. The cumulative value of the regenerated resources will be up to about 20.63 billion USD. The cumulative amount of CO2 reduction will reach to about 11.32 million tonnes only by physical diassembly. Starting from 2044, the regenerated metal resources supply from the annual PV panel waste recycling may gradually meet the metals demand required for the annual PV panel production. The study provides a scientific base for the sustainable management of PV panel waste recycling in a region.

Paper ID: 270

Enhancing soil and crop health: impact of nZVI-biochar on chromium bioavailability and uptake in rice

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Abstract:
Chromium (Cr) accumulation in soil has led to significant pollution of agricultural land. Thus, it is crucial to remove Cr(VI) from the soil efficiently and sustainably. Currently, nano zero-valent iron (nZVI) is viewed as a promising material for remediating Cr-contaminated soil. But it's still unknown how nZVI affects the behavior of Cr in the soil-rice system, especially in places where natural geological background levels are high. This study investigated the impacts of zero-valent iron (ZVI) and/or biochar amendments on Cr bioavailability in rice through pot trials. The results showed a notable reduction in Cr accumulation in various rice tissues when using ZVI-biochar amendments compared to untreated soil. Specifically, Cr concentrations in rice grains decreased by 79% relative to untreated soil. The ZVI–biochar combinations enhanced the conversion of bioavailable Cr fractions into less bioavailable fractions, demonstrating the synergistic effects of biochar and ZVI. When compared to untreated soil, the microbiological quality and enzyme activity of the biochar-loaded nZVI dramatically enhanced. According to the findings, the treatments raised the pH of the soil solution while lowering the amount of bioavailable Cr in the soil. When compared to the control treatment, the amendment application improved the plant-height, shoot and root dry mass, and grain yield in a dose-additive manner. When nZVI-biochar was applied to untreated soil, it resulted in a decrease in oxidative stress and an increase in photosynthetic pigments in leaves. All things considered, using nZVI-biochar may be useful in immobilizing Cr in the soil and lowering its absorption and translocation to grains.

Paper ID: 271

Main CE practices in the Construction industry for the six carbon-intensive materials

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Abstract:

CE practices are Refuse, Rethink, Reduce, Reuse, pave the way for the construction sector to become less material- and carbon-intensive. However, for CE quantification by climate mitigation models, one must first identify the CE practices along a product (or material) value chain. In this review, we map CE practices used within the value chain of 6 construction materials to understand how these practices influence and can be considered in climate mitigation modelling. The main sub-categories of steel, cement, glass, clay-brick, insulation materials, and wood were used to identify which Rs are currently addressed at the lab and industrial scales: refuse, reduce, rethink, repair, reuse, remanufacture, refurbish, repurpose, recycle, and recover. The CE practices were reviewed using scientific repositories and grey literature, validated by European-wide stakeholders. Although ideally, the CE practices should be mapped across all the life-cycle stages of the six materials – extraction, manufacturing, use, and end-of-life (EoL), this was limited to the manufacturing and EoL stages. This is because it was found that information for the construction materials could be identified mainly at these stages since the extraction phase pertains to resources, such as sand, and not to materials, and the use phase focuses on products, for example, buildings. All reviewed CE practices that were identified to be implemented at the industrial scale were quantified at the European level. For example, regarding EoL reinforcement steel, it was found that 1-11% is currently reused in the EU and 70-95% is recycled. CEM I manufacturing is reduced by up to 60% by using supplementary cementitious materials in the making of concrete. A major barrier to closed-loop recycling is the need for sorting and separation technologies. On the other hand, open-loop recycling synergies are found at the industrial scale between, for example, flat glass and glass wool value chains.

Paper ID: 273

Liquefaction of different industrial lignins as a method to generate renewable chemicals

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Abstract:
Lignins are a major structural component of plants, making up a large proportion of agricultural and horticultural waste biomass. This abundant and underutilized resource presents a significant opportunity for the production of renewable carbon-based chemicals. Notably, most waste lignins are produced through technical processes in the paper and pulp industry, with the structural characteristics of these industrial lignins varying depending on the type of pulping process used. Hydrothermal liquefaction (HTL) is emerging as a promising method for converting waste lignins into valuable chemical compounds. This process offers a sustainable pathway to produce chemicals that are of significant interest to the food, fragrance, and pharmaceutical industries. In this study, we have conducted a comprehensive investigation of the HTL process applied to various industrial lignins. We focus on understanding the influence of technical lignins on the types of chemical compounds produced during HTL. Our results reveal that the HTL process can effectively convert lignin into a range of valuable chemical compounds. These compounds can be further upgraded and refined for various applications, including as bio-based feedstock for high-value products in multiple industries.

Paper ID: 275

Hidden delay of emission mitigation benefits for deploying photovoltaic systems in electric vehicle charging stations

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Abstract:
Adopting photovoltaic (PV) systems can provide clean and sustainable solar energy for electric vehicle (EV) charging. However, the emission mitigation benefits are not gained immediately, as the manufacture and construction of PV systems retain non-neglectable carbon footprints, laying a greenhouse gas (GHG) debt to be paid back in the use phase. This study aims to quantify the paid-back period of the GHG debt from deploying PV systems for EV charging in various regions of China, revealing the impacts of different PV system manufacturing technologies, charging demand, solar radiation intensities, and carbon intensity of electricity generation. A cradle-to-gate life cycle assessment approach is used to model the carbon footprint from PV manufacture, and a quasi-input-output model is adopted to quantify the carbon intensity of electricity generation at the hourly resolution. The finding can help policymakers understand the duration to obtain emission mitigation benefits of deploying PV systems to decarbonize EV charging in China.

Paper ID: 276

Tracing environmental footprints of urban food consumption along global supply chains and mitigation strategies—a case study in China

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Abstract:

The food system plays a significant role in global resources and environmental sustainability. Meanwhile, the rapid urbanization and globalization processes have brought profound changes of the food system and its resources and environmental stress, causing tele-coupling of food production and consumption as well as transboundary impacts. However, empirical research on simulation and assessment of transboundary environmental impacts of urban food systems and potential mitigation strategies has been rare. This study aims to trace environmental footprints of urban food systems and explore city-level regulatory strategies, from a supply chain perspective. Taking Xiamen (highly urbanized and consumption-oriented) in China as a case city, the carbon, nitrogen and phosphorous footprints are evaluated. The results show that the per capita footprints of food consumption in Xiamen in 2015 are 617.12 kg CO2e, 11.91 kg N, and 1.09 kg P, respectively. In terms of spatial patterns, the city transfers 36.3%, 19.5%, and 39.0% of carbon, nitrogen, and phosphorous emissions to areas outside Fujian Province (where Xiamen is located), indicating obvious transboundary transmission of environmental stress. In terms of sectoral patterns, both nitrogen and phosphorous emissions are dominated by the “Agriculture” sector, while for carbon emissions more sectors have substantial contributions. Besides, regional heterogeneity exists in the sectoral distribution of carbon emissions, facilitating precise identification of key sectors in critical regions and regulatory paths. Three urban strategies—optimizing local production efficiency, adjusting supply structure, reducing food waste—are analyzed, and the former two have larger mitigation potential (-16% to -22% of footprint changes) than the last one (-5% to -6% of changes). Efficiency optimization should focus on livestock and poultry products; structural adjustment should notice the potential trade-offs among different sectors in their environmental effects; and it is suggested to pay special attention to the waste of vegetable oil while implementing waste reduction strategy.

Paper ID: 277

Understanding critical data needs in waste LCA tools for climate change mitigation

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Abstract:
Waste management decision makers often rely on LCA findings to determine effective strategies to reduce environmental impacts, of which climate change mitigation has become centerstage. The complexity of conducting an LCA for waste management decision making is typically simplified using comprehensive models developed for wide region (e.g., United States, United Kingdom, Denmark) containing geographic and temporal metadata particular to the region. Recent waste management focused LCA studies cite dated metadata which contribute to results uncertainty and many studies do not identify critical inputs. The aims of this study are to: 1) determine hotspot assumptions triggering the greatest sensitivity to the global warming potential (GWP) indicator for the management of various waste components in the US; and 2) inform on data collection approaches decision makers may use to improve their waste LCA. A perturbation analysis was conducted for several recycling, landfilling, and combusting parameters using the Solid Waste Optimization Framework (SWOLF) Model. The analysis was first conducted by creating a baseline with default SWOLF assumptions and then on an individual material basis (e.g., aluminum cans, glass, cardboard, food waste) a 5,000 iteration Monte Carlo perturbation analysis was done for each parameter and management. For landfilling, critical assumptions included landfill gas management factors such as lifetime gas collection efficiency, the type of gas management employed, and the bulk decay rate. In recycling, the most influential factor was the material substitution ratio. For combustion, key parameters were the avoided emissions from the electrical grid mixture and the types of metals recovered from the ash. Whenever data is available it should be supplemented in place of defaults to reduce uncertainty in waste LCA tools, especially the parameters highlighted that have influential impacts on results.

Paper ID: 278

Life cycle assessment of polyethylene and alternative packaging materials in the United States

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Abstract:

Packaging plays a crucial role in society, ensuring product containment, protection, and preservation. However, the growing consumption of packaging, often linked with economic growth and prosperity, has sparked interest in assessing and comparing the potential environmental impacts of different packaging materials. This life cycle assessment study covers cradle to end-of-life (use phase impacts, e.g., breakage and shelf life, were excluded) and compares the potential environmental impacts of polyethylene-based (PE) packaging and the alternatives. Nineteen packaged products were assessed across five prevalent PE packaging applications (collation shrink film, stretch film, heavy-duty sacks, non-food bottles, and flexible food pouches) using five environmental impact assessment categories (Global Warming Potential with and without biogenic carbon, Fossil Resource Use, Water Scarcity, and Mineral Resource Use). For the 5 impact categories and 19 alternative solutions considered, PE-based packaging had a lower potential environmental impact in 77 of 95 (81%) packaged product comparisons. The study provides insights on potential environmental impacts of key packaging applications and highlights the material efficiency of PE-based packaging in reducing potential environmental impacts. It suggests that the potential environmental impacts are a function of packaging weight, design, and non-paper components enabling paper-based packaging. These insights empower decision-makers in the packaging industry and beyond, contributing to a greater understanding of the potential resource use and environmental impacts of various packaging materials and enabling them to make more informed decisions.

Paper ID: 281

Linked data-driven decision support for intelligent electric vehicle charging in urban energy management

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Abstract:
Electric vehicles (EVs) have been a promising strategy for sustainable transition in the transport sector by integrating electricity consumption and storage and supporting sustainable mobility. However, the increasing energy demand for EV charging poses challenges such as grid congestion and energy resource management difficulties. Addressing data silos in the decision-making process can mitigate issues of data integration, information interoperability inconsistencies, and the lack of unified standards, accordingly, enhancing the efficiency of EV charging management. This study aims to develop a novel ontology to enhance data integration, thereby supporting EV charging demand estimation and decision-making on EV charging strategies. The research begins with the identification of the various factors, knowledge, and technologies influencing EV charging. Building on these insights, the study developed an ontology that integrates multi-domain data, including energy (such as renewable energy production), technology (including renewable energy systems and different charging technologies), and information (such as neighbourhood and building information, user behaviour, time series weather data, and geographic information). Subsequently, the study converts heterogeneous data into semantically linked data to facilitate effective information integration. The study employs Eindhoven, Netherlands as a case study to validate the developed ontology. Employing semantic web technology, this research integrates diverse domains of knowledge and data into semantically linked data. The developed ontology equips decision-makers with decision-makers with support for estimating EV charging demand, developing charging strategies, and optimising urban energy management. The study contributes to balancing the benefits of EV adoption with the challenges it poses to urban energy systems. It promotes sustainable development goals and facilitates energy transition, enhancing the integration and management of electric vehicle (EV) charging information within urban settings, and supporting decision-making in energy management strategies.

Paper ID: 282

"Unconventional High-Value Utilization of Boron Industrial Solid Waste in the Field of Shielding" Materials

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Abstract:

Boron ore is a scarce and strategic mineral resource widely used in the production of boron and borides. However, the large-scale storage of boron-containing solid waste (BCSW) generated from boron ore mining has become a significant bottleneck constraining the sustainable development of the industry. Therefore, we have delved into the resource and environmental attributes of BCSW. Through a detailed analysis of its material compositions, we innovatively propose a non-conventional resource utilization path, that is, the preparation of hydrogen-rich polymer-based shielding materials with high added value from the waste. Initially, we confirmed the commercial value of BCSW and successfully developed composite shielding materials with performance surpassing commercial shields. Subsequently, through experiments, computational simulations, and in-depth theoretical analysis, from a macroscopic to microscopic multiscale perspective, we comprehensively elucidated the evolution laws of the microstructures of these composite shields and their multiscale attenuation mechanism. This study provides a solid scientific basis and a technological prototype for the application of BCSW in the field of shielding materials.

Paper ID: 283

Harnessing calcium precipitation for sustainable biogas slurry management

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Abstract:
In biogas slurry (BS), various components including suspended solids (SS), heavy metal ions, microorganisms, emerging contaminants, and plant nutrients coexist, posing both environmental challenges and resource potential. Effective SS removal is crucial for mitigating pollution. Traditional coagulation methods, widely used in water treatment, often fail to adequately treat super-stabilized BS colloids. This limitation presents a significant hurdle for sustainable biogas plant operations. To address these challenges, we developed a straightforward and efficient process called alkaline calcium precipitation. This method involves adjusting pH and adding low-cost calcium chloride to facilitate rapid SS separation from BS, while simultaneously recovering nitrogen and phosphorus nutrients. Under strongly alkaline conditions (pH 12), increasing calcium chloride dosage enhances SS sedimentation, achieving up to 49.76% removal at a 5% dosage. Additionally, 39.23% of ammonia and all phosphate are effectively transferred to the solid phase. The mechanism involves divalent calcium ions neutralizing the negative charge on SS, reducing colloidal stability. Furthermore, at pH 12, bicarbonate in the slurry converts to carbonate, facilitating the formation of calcium carbonate compounds that aid in SS capture. Ultimately, this gravity-driven process offers a cost-effective alternative to conventional coagulation methods, reducing BS pollution and maximizing nutrient recovery from digestate. In engineering applications, the alkaline calcium precipitation process effectively reduces the pollution potential of BS while maximizing nutrient recovery. This approach offers a viable, cost-effective solution for both the treatment and resource utilization of biogas slurry, supporting the overall sustainability of biogas plant operations.

Paper ID: 284

Efficient valorization of sewage sludge via phytohormones production: A short-cycle, low-energy, high-value process.

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Abstract:

Sewage sludge (SS) concentrates over half of municipal wastewater pollutants, posing a significant global water industry challenge. Proper treatment of SS helps to reduce water pollution (SDG6) and develop clean energy (SDG7) in support of the United Nations Sustainable Development Goals (SDGs). By reducing the environmental pollution caused by SS treatment, it can enhance the Sustainability Cities and Communities (SDG11), promote Responsible Consumption and Production (SDG12) by utilizing the nutrients in SS, and mitigate the impact of climate change by reducing greenhouse gas emissions (SDG13). The management and utilization of SS has profound significance in terms of resources recycling and sustainable development. Existing SS treatment technologies (anaerobic digestion, incineration and aerobic fermentation) fall short in terms of carbon emissions, process efficiency, and resource recovery. Therefore, a short-cycle, low-energy, high-value management process is urgently needed. This study focuses on alkaline hydrothermal treatment, proposing a cost-effective approach for sludge valorization. Here, we investigate the impact of treatment duration, temperature, and solid content on the synthesis of high-value products, as well as their effects on the composition and properties of the solid and liquid phases. The resulting products, including phytohormones, humic substances, and essential nutrients (C, N, P and K), exhibit substantial potential for high-value agricultural utilization. Notably, the total content of phytohormones, represented by auxins, jasmonic acids, cytokinins, and salicylic acids, can reach up to 104 μg/L. Heavy metal content of the liquid fertilizer product is much lower than the standard limits in many countries and regions such as China, the US and Europe. In terms of solid, substantial volume reduction and biological stability are achieved simultaneously. This process is 42.12 times more energy-efficient than conventional anaerobic digestion. This novel approach enables water utilities to establish a more economically viable SS management pathway, promoting waste resource recycling and sustainable urban management.

Paper ID: 285

Comprehensive study of polyethylene-based packaging and its substitutes on the European market – focus on GWP, water scarcity and fossil energy

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Abstract:

Plastics are lightweight, versatile, and valuable materials used across a wide range of applications and industries, from transporting goods and packaging products to protecting and preserving food. The topic of waste and potential environmental impacts from the use of plastic in packaging continues to be a global discussion topic and is a focus of the Packaging and Packaging Waste Regulation (PPWR) in the European Union. Noting that Polyethylene (PE) is the main polymer type in the packaging sector, a comprehensive and comparative cradle-to-end-of-life LCA study of PE-packaging with alternatives (paper, glass, metal) was performed for the European region to understand the Global Warming Potential (GWP) and potential resource use (fossil energy consumption and water scarcity) impacts. The use phase impacts, e.g., breakage, shelf life, were excluded in the study. The study, which focused on 5 large volume PE applications (collation shrink film, stretch film, heavy-duty sacks, non-food bottles, and flexible food pouches) and covered 37 product groups where both PE packaging and alternatives were found in the market. More than 90 packaging formats were assessed, resulting in 50 comparisons of PE packaging with the alternatives. For all the assessed packaging applications, PE-based packaging showed lower GWP in 34 of 50 (68%) comparisons, lower water scarcity in 22 of 50 (44%) comparisons and lower fossil resource use in 23 of 50 (46%) comparisons. Banning or restricting the use of plastics such as PE in certain applications would lead to higher greenhouse gas emissions and associated impacts. Therefore, selecting packaging formats to enable the lowest overall environmental impact in supply chain is a complex process that requires comprehensive analysis.

Paper ID: 286

A novel process combining heat treatment and magnetic separation to recover critical metals from used Li-ion batteries

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Abstract:
With the growing demand for electrification of automobiles and portable electric devices, the global need for critical metals such as cobalt, nickel, and lithium used in lithium-ion batteries (LIBs) continues to increase. Given the finite reserves of these critical metals, the development of LIBs recycling technologies has become indispensable to ensure their sustainable supply. In the recycling of used LIBs, LIBs are first discharged, heat-treated, crushed, and sorted to produce black mixed powder (i.e., black mass) that contains cathode and anode active materials. Cobalt, nickel, lithium, and other elements are recovered from this black mass through pyrometallurgical or hydrometallurgical processes, but numerous technical and economic challenges exist, particularly in the recovery of lithium. In this study, we proposed an efficient lithium recycling method that utilizes thermal treatment and magnetic sorting of LIBs. Specifically, spent LIBs were heat-treated at an appropriate temperature to change the cathode active material into a magnetic material, and then crushed and sorted to recover black mass. The black mass was then magnetically sorted, yielding a cobalt-nickel enriched magnetic product and a lithium enriched non-magnetic product. The content of cobalt and nickel in the magnetic product was approximately twice compared to that of the black mass. Furthermore, a high purity lithium carbonate (≥99%) could be produced from non-magnetic product via acid leaching followed by impurity removal and lithium precipitation.

Paper ID: 287

Effects of experience, knowledge, and preparedness on natural disaster risk perception: A comparison of environmental and non-environmental students in Vietnam

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Abstract:

Risk perception has become an increasing concern in the context of natural disasters that tend to increase and impact many aspects of human life, including students. This study aimed to investigate the effects of experience, knowledge, and preparedness on the risk perception of future natural disasters by comparing environmental and non-environmental students. A questionnaire survey with random sampling was conducted in April and May 2024 for 107 students of environment-related majors and 182 students of non-environmental majors at the University of Sciences, Hue University. Hue, Thua Thien Hue province, is one of the most disaster-prone places in Vietnam. After referring to some models by Bronfman (2020) and Guo (2020), a relationship model of these factors was created. The suitability of survey questions was assessed using Cronbach's alpha and exploratory factor analysis with the maximum likelihood method. Then, a structural equation model was used to examine the effects of experience, knowledge, and preparedness on risk perception. The estimated models achieved acceptable levels of Goodness-of-Fit to the data. The findings showed similarities in these relationships between the two groups. Preparedness had a statistically significant positive impact on risk perception about future damage and scarcity of natural disasters for both groups. The effects of experience and knowledge on risk perception were not statistically significant. Considering the factors that positively affect risk perception will provide a basis for increasing student awareness about natural disasters.

Paper ID: 288

A crisis hiding in plain sight – a scoping review of the rapidly growing sachet economy

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Abstract:
The global plastics crisis is forcing us to acknowledge the disproportionate impacts of plastic waste in Low and Middle Income countries and the environmental unsustainability of single-use items such as bags, cups and straws. As annual consumption of single portion multi-layer non-recyclable sachets approaches 1 trillion, we assert that the absence of attention on the impacts of this packaging format has enabled an environmental and socioeconomic disaster to unfold, hidden in plain sight. Our scoping review used the PRISMA-ScR method and a revised waste hierarchy to reveal knowledge gaps being filled by Institutions and NGOs rather than academia, particularly where alternatives to the sachet economy at the top of the waste hierarchy are addressed. Policymakers and consumers in The Philippines and Indonesia were found to be the most common target audience and geographical context, but with a high proportion of grey literature introducing the potential for bias, and reduced rigour and impact. The collation of results was hampered by heterogeneous descriptive terms and language, making the extent of research relevant to the sachet economy difficult to quantify. Our research highlights the urgency for increased awareness and robust research to inform policymakers and consumers regarding the reach and impacts of and alternatives to sachets. This includes quantification of the contribution of sachets to flooding, freshwater pollution and ocean plastics, and economic impacts on sachet users. Without swift attention, we assert the sachet economy and associated environmental and socioeconomic damage, will continue to grow in South East Asia and spread quickly to low income economies in Africa, where sachet use is already starting to increase.

Paper ID: 289

Blending as an approach to maximizing beneficial use of waste materials while maintaining protection of human health and the environment

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Abstract:
The global production of waste materials continues to expand with an ever-growing population. Simultaneously, demand for construction products grows, and many of these natural materials, such as limerock or granite, are finite. Interest in use of waste products to supplement construction materials has increased, to meet resource demand and promote UN sustainability goals. Examples include the beneficial use of industrial byproducts, like phosphogypsum (PG) or municipal solid waste incineration (MSWI) bottom ash (BA), in road construction. However, prior to implementation, the physical and chemical performance should be evaluated to ensure the final product is suitable for use and protective of human health and the environment. This includes mechanical parameters such as strength and environmental considerations such as direct exposure and leaching to groundwater risk. Challenges involve producing marketable products for the industry and identifying an appropriate methodology to evaluating these materials. Here, we present an approach to use these two industrial byproducts, MSWI BA and PG, as a construction aggregate in road construction and detail the opportunities and challenges associated with these methods. By discussing two case studies, we showcase over a decade of research regarding optimization of these materials for use as road base product in the United States. This information benefits operators, stakeholders, and industry and research professionals looking for ways to navigate reuse of other industrial byproducts.

Paper ID: 290

Development of an automatic operation process for a continuous jig separator -Appropriate heavy/light particle layer boundary measurement and upwelling velocity measurement-

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Abstract:
Jig, a common wet-gravity separator, has been widely applied to mineral processing and resources recycling. In jig separation, heavy and light particles are stratified in the separation chamber, and thus the position of the boundary between heavy/light particle layers as well as appropriate velocity of upwelling are important factors determining separation efficiency. In this study, the pressure loss across the particle layers was investigated during jig separation of the plastic samples, and the relationship between the boundary position and pressure loss was discussed. Jig separation experiments were conducted using heavy and light plastic particles, and pressure loss during a 4-step water pulsation cycle (i.e., (1) rising, (2) holding, (3) downwelling, and (4) holding) was investigated. In the 1st step, particles rose with upstream water flow, and pressure loss increased with time. In the 2nd step, particles started to settle down in the chamber, while pressure loss decreased with time. In the third step, the particles were anchored to the bottom, so the pressure loss decreased once and then increased, approaching zero. This relationship was used to estimate upwelling velocity. Float sensors, water level sensors, and water pressure sensors were used to observe the boundary and pressure loss. By setting the specific gravity of the float of the float sensor between heavy and light particles, the position of the boundary surface can be measured. If the boundary can be measured and controlled, a high grade and high recovery can be achieved in the recovery process of continuous jigs. The water level sensor measures the position of the water surface, and the water pressure sensor measures the water pressure to determine the pressure loss and velocity of upwelling. By using these two values, it is possible to estimate whether the upwelling velocity is appropriate or not.

Paper ID: 291

How does China's Renewable Portfolio Standard promote renewable energy development? Empirical evidence based on spatial spillover effect and pressure perspective

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Abstract:
China's government has promulgated the Renewable Portfolio Standard (RPS) to solve the problem of excessive wind and solar curtailment in developing renewable energy. However, the impact of the Renewable Portfolio Standard on the development of renewable energy and the specific impact mechanism remains unexplored. To study how China's RPS affects renewable energy development, this study analyzes from two perspectives: central government pressure and peer pressure among provincial governments, using panel data of 30 provinces from 2010 to 2022. This study applies the spatial Durbin model and spatial autoregression model to discuss the spatial effects of two types of pressure. The results show that the target set by the central government can effectively increase the proportion of renewable energy in the power generation mix, and the excellent performance of the surrounding provinces of a province in renewable energy development can effectively promote the renewable energy development of that province. The study finds four possible mechanisms of the RPS affecting renewable energy development: limiting renewable energy investment, reducing energy facility construction, enhancing regional grid cooperation, and promoting green innovation. Besides, this paper finds that the RPS may have more significant promoting effects in provinces that implement collaborative policies such as the Photovoltaic Poverty Alleviation policy and whose production activities are highly dependent on electricity. The results reveal that under the pressure of repeated assessment of energy intensity, the policy effect of the Renewable Portfolio Standard may be weakened. In addition, through heterogeneity analysis, this paper finds that the evaluation targets of surrounding provinces will effectively promote the development of renewable energy among high electricity-exporting provinces, while this impact is negative among provinces with low external power transmission. Finally, this paper proposes policy recommendations for the government to promote renewable energy development further.

Paper ID: 292

Facile synthesis of Fe:Co bimetallic metal organic framework (MOF) for highly selective CO2 capture

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Abstract:
Anthropogenic CO2 mitigation is one of the ways to reduce greenhouse gas emission to the environment. A CO2 adsorber has been developed in this work via a rapid microwave process by mixing Fe and Co metal precursors with benzene dicarboxylic acid (BDC) to form a bimetallic metal-organic framework (MOF). The spindle-shaped MIL-88B topology was obtained from the bimetallic MOF samples synthesized with the Fe:Co metal ion ratio of 2:3. The bimetallic MOF showed the presence of coordinatively unsaturated metal sites, which resulted in the formation of highly active open metal sites, making it an acidic MOF. The acidity originates from the charge imbalance in the mixed valence substitutions of Fe(III) and Co(II) in the MIL-88B topology under quick synthesis, leading to the creation of metal centers with incomplete coordination. The monometallic Fe-BDC and Co-BDC MOFs have shown N2-BET surface area of 24 m2g-1 and 8.8 m2g-1, respectively, while 2:3 Fe:Co-BDC bimetallic MOF have shown a higher N2-BET surface area of 79 m2g-1 with the total pore volume of 0.067 cm3g-1. Moreover, the bimetallic MOF could adsorb ~0.99 mmol g-1 of CO2, which was higher than their monometallic counterparts (0.39 mmolg-1(Fe-BDC), 0.11 mmolg-1(Co-BDC)). The CO2 selectivity over N2 was ~40.2 times. Hence, this revealed the significance of coordinatively unsaturated metal sites in the bimetallic MOF for highly selective towards CO2 due to their strong acidic properties serving as effective adsorption sites. Furthermore, the quick growth of bimetallic MOF in 20 mins of reaction time via microwave irradiation reduces the time required for MOF formation and energy consumption from a few hours to a fraction of mins. The overall synthesis protocol provides a platform to develop gas adsorbers with highly active sites for CO2 adsorption, with a unique microcrystal shape and distinct properties, making it an excellent material for various applications.

Paper ID: 293

Upcycling solid wastes: synthesis of Zn/Fe bimetallic MOF from electroplating sludges and PET waste bottles for CO2 capture

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Abstract:

A value-added bimetallic Zn/Fe metal-organic framework (MOF) has been synthesized successfully from waste polyethylene (PET) bottles and electroplating sludges (EPS). PET was depolymerized to benzene dicarboxylic acid (H2BDC) linkers via balling milling PET flakes with NaOH pellets. Zn/Fe bimetal was extracted from the electroplating sludge via HNO3 acid leaching. The PET-derived H2BDC linkers and metal ions from EPS were subjected to solvothermal at various temperatures and reaction times under microwave irradiation to form the Zn/Fe bimetallic MOFs. The formed bimetallic MOFs have shown characteristic FTIR and PXRD patterns for both Zn and Fe MOF with a mixed morphology of diamond/spindle/layer shapes. The Zn/Fe bimetallic MOF prepared at 100 °C for 30 mins has shown the highest BET surface area of 500 m2g-1 with a total pore volume of 0.33 cm3g-1. Zn/Fe MOF-100 demonstrated the highest adsorption capacity of 1.00 mmol g-1 at room temperature and atmospheric pressure, which was relatively higher than the other synthesized bimetallic MOFs. The structural changes observed in the PXRD patterns indicate the formation of different phases of Zn/Fe BDC MOFs. Specifically, Zn/Fe MOF-80 and Zn/Fe MOF-100 exhibit a characteristic peak around 5.3°, which could be correlated to their structure-dependent higher CO2 adsorption capabilities. It also showed higher CO2 selectivity over N2, approximately 28.52 times determined through a single gas component studied. Therefore, this work demonstrates the platform to utilize solid plastic waste, which is emerging drastically, and the innovative use of heavy metals from electroplating sludge to obtain valuable porous material in a cost-effective and eco-friendly manner. Meanwhile, this green process conserves available resources by upcycling hazardous metal sludges and PET wastes into MOFs, which have the potential for capturing and storing greenhouse gases. The derived value-added product also could be employed as an adsorbent for other environmental remediations.

Paper ID: 295

Elevated methane production and microbial community shifts through the removal of phenolic compounds from palm oil mill effluent

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Abstract:
This study investigates the impact of phenolic compound removal from raw Palm Oil Mill Effluent (POME) on methane production under anaerobic digestion systems. Results from small-scale experiments to large-scale demonstrations consistently showed significant enhancements in methane yield and process efficiency. Under small-scale experiments, using the inoculum: raw POME: extracted POME in a 5:0:1 ratio resulted in a maximum cumulative methane yield of 559.80 mL-CH4/g-VS, approximately 2.68 times higher than the ratio of 5:1:0, which produced 208.90 mL-CH4/g-VS. The maximum methane production rate (MMPR) for the ratio of 5:0:1 was 125.90 mL-CH4/g-VS·day, compared to 24.72 mL-CH4/g-VS·day for the ratio of 5:1:0. Microbial community analysis revealed dynamic changes, with Trichococcusincreasing from 63.22% on Day 0 to 69.00% on Day 3, then decreasing to 55.22% on Day 15. Syntrophaceticus, a syntrophic acetate-oxidizing bacterium, was found to predominate on Day 15, with an abundance of 6.38%. The relative abundance of Methanosaeta gradually increased from 88.75% on Day 3 to 97.36% on Day 15 in the ratio of 5:0:1, highlighting its role in converting acetic acid to methane. In large-scale experiments, the ratio of 5:0:1 yielded 1221.00 mL-CH4/g-VS, approximately 7.7 times higher than the 158.50 mL-CH4/g-VS produced by the 5:1:0 ratio. The MMPRfor the ratio of 5:0:1 in the large-scale setup was 124.10 mL-CH4/g-VS·day, significantly higher than the 16.85 mL-CH4/g-VS·day for the 5:1:0 ratio. In addition, the removal of phenolic compounds also reduced the digestate toxicity, facilitating safer environmental discharge. This study demonstrates that phenolic compounds removal significantly improves methane yield and process efficiency, offering a sustainable and viable strategy for biogas production from POME. This contributes to environmental sustainability and resource recovery.

Paper ID: 296

Application of XGBoost for Retrieving PM2.5 Concentrations from AOD and Meteorological Data in Hyderabad, Telangana

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Abstract:
Air pollution is a significant global concern, largely driven by human activities. Among various pollutants, particulate matter (PM), comprising tiny solid or liquid particles in the air, varies in size, notably PM10 and PM2.5, with PM2.5 being a major public health concern due to its ability to penetrate deep into the lungs and enter the bloodstream. Prolonged exposure to high levels of PM2.5 is linked to respiratory and cardiovascular issues like asthma, bronchitis, and heart attacks. This study focuses on retrieving PM2.5 concentrations from aerosol optical depth (AOD) and meterological variables like temperature, and relative humidity at Zoo Park, Hyderabad, Telangana. Extreme Gradient Boosting (XGBoost), a machine learning model, was used for prediction, efficiently addressing data gaps and ensuring model accuracy. The study also compares predicted PM2.5 concentrations with ground-based data for validation. The findings demonstrate the XGBoost model's robustness in retrieving PM2.5 concentrations, with a margin of error of 15-20%. A strong correlation coefficient of 0.9 was found between PM2.5 values retrieved from AOD and measured concentrations, affirming the model's reliability. In conclusion, the XGBoost model is an effective tool for PM2.5 retrieval, offering valuable insights for air pollution monitoring.

Paper ID: 297

Configurational research on high-performance development of hydrogen fuel cell vehicle enterprises: a fsqca analysis based on toe theoretical framework

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Abstract:
The hydrogen fuel cell vehicle (HFCV) market is undergoing rapid expansion. Nevertheless, it encounters several challenges requiring resolution, such as technical constraints and restricted market dimensions. Consequently, further research is imperative to explore how to promote the high-performance of enterprises in this industry. Employing the fsQCA method, this study scrutinizes the multifaceted simultaneous impacts of technological, organizational, and environmental conditions on the evolution of 40 Chinese HFCV enterprises, analyzed from a configuration perspective. The results indicate that the high-performance of HFCV enterprises is collaboratively determined by variables including R&D capability, human capital level, scale of enterprise, attention allocation, and government support. Three configurations were identified as catalysts for high-performance, namely, technology-driven, internal-external synergy, and organization-policy-driven. Without adequate government support and human capital, achieving high-performance of HFCV enterprises appears improbable. These findings furnish a comprehensive framework, rendering both theoretical guidance and practical assistance for the future development of HFCV enterprises.

Paper ID: 299

Sustainable hydrothermal carbonization (HTC) of yard waste using domestic wastewater as reaction medium

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Abstract:
Hydrothermal carbonization (HTC) has emerged as an effective method for processing wet wastes, offering advantages over traditional biological and thermal treatments through faster processing times and lower operating temperatures. However, the reliance on distilled water (DW) in large-scale HTC operations poses a significant challenge due to the rapid depletion of water resources. This study investigates the viability of using domestic wastewater (WW) as an alternative reaction medium for the HTC of yard waste (YW). A central composite design within the framework of response surface methodology (RSM) was employed to optimize HTC conditions, focusing on temperature (180-240°C) and time (60-240 minutes). The study aimed to enhance key response variables: mass yield (MY), higher heating value (HHV), and energy yield (EY). Physicochemical characterization, including proximate and elemental analysis, was performed, with HHVs calculated using Dulong's formula. RSM results identified optimal HTC conditions for YW in DW at 184.1°C for 60 minutes, yielding an MY of 71.1%, HHV of 16.42 MJ/kg, and EY of 75.8%. For WW, optimal conditions were 187.5°C for 60 minutes, yielding an MY of 72.2%, HHV of 16.93 MJ/kg, and EY of 77.7%. The Van Krevelen diagram confirmed that the synthesized hydrochars fall within the lignite coal range, highlighting the HTC process's capability to produce solid biofuel. Thermogravimetric analysis revealed that hydrochars have a more stable combustion profile compared to the feedstock, with hydrochars produced using WW (YWH-WW) exhibiting enhanced thermal stability over those produced with DW (YWH-DW). This study demonstrates that utilizing WW as a reaction medium for the HTC of YW in a pilot-scale reactor not only reduces freshwater consumption but also decreases the load on sewage treatment plants. Additionally, this approach generates a solid biofuel, offering a sustainable alternative to fossil fuels.

Paper ID: 300

A comparative life cycle assessment of semi-prefabricated houses from cradle to site

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Abstract:
With a staggering 37% share of worldwide emissions, the building and construction sector is one of the largest emitters of GHGs. Construction materials such as cement, steel, and aluminium have a substantial carbon footprint during their production and utilization. Implementing modular design and prefabricated techniques can reduce construction waste and carbon emissions by about 40%, compared to conventional construction methods. Additionally, GHG emissions from on-site energy consumption and waste as well as worker transportation in conventional construction can be significantly reduced. This study aims to demonstrate the environmental impacts of a semi-prefabricated house from cradle to site and to propose methods for reducing carbon footprint during house design, material selection, and construction processes. A LCA was used to evaluate environmental impacts, including GWP and PM2.5 formation, as well as damage to human health, ecosystems, and resource availability. Two different semi-prefabricated house designs – modern and traditional styles, each with a usable area of 200–300 square meters – were compared. The LCI data was collected by reviewing the bill of materials from a building construction service provider, collecting information from 8 construction sites around urban and sub-urban areas of Bangkok, and interviewing project managers and site engineers. SimaPro software version 9.6.0.1 with the ReCiPe 2016 Midpoint and Endpoint (I) V1.09 evaluation method was employed. The results indicated that over 90% of the environmental impact came from construction waste. When focusing on the product and the construction process stages, including on-site transportation and installation, the highest carbon footprints were contributed from phases 1 (building foundations, accounted for 32.32 tons CO2-eq), 4 (bricklaying work, accounted for 23.65 tons CO2-eq), and 3 (roof structure framing, accounted for 23.59 tons CO2-eq). Furthermore, the study found that the modern-style house (with flat-slab style) tends to have a more environmentally friendly design, at about 18% carbon reduction.

Paper ID: 301

Nearly zero energy buildings with low-exergy radiant heating/cooling systems using RES

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Abstract:
We live in a time when climate change is increasingly forcing us to deal with the question of the right choice of heating or cooling system for living spaces. Due to global warming, we are experiencing milder winter seasons and then, without a pleasant transitional period of spring, we find ourselves in hot summer days. Based on EPBD Directive 2018/844/EU countries requires nearly zero energy buildings which means applying of renewable energy sources. One option for both heating and cooling design is the use of water-based radiant systems. Radiant systems are particularly suitable for combination with renewable sources, provide high sensible output and can be used for both heating and cooling. Compared to other systems, large-area radiant systems provide a fundamentally more even distribution of temperatures indoors. The common characteristic of all these RES systems is low potential of energy, for example in low temperature heating for the winter period and high temperature cooling for summer period. There are low exergy radiant systems, which can emit heat/cool using the surface of the surrounding building constructions. The heat output of such systems is between 100 and 400 W/m2 for heating and between 50 and 150 W/m2 for cooling. At present such systems are very often used in our country for supplying by heat/cool especially in office buildings. The paper familiarizes the reader with the basic idea of the low-exergy radiant systems, describes the method of using renewable energy sources in these systems. The paper concludes with an example of an administrative building in which the described system is applied. An important advantage of radiant systems is a good combination with such as heat pumps, solar collectors, industrial waste or existing natural water sources. Low

Paper ID: 305

Development of a constructed wetlands-based system for the treatment of landfill leachate

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Abstract:
A landfill in Florida examined alternate and more sustainable leachate management practices that could be implemented on-site. The result of this evaluation was the conceptualization of a 9-acre constructed wetlands-based system for the treatment of landfill leachate. Constructed treatment wetlands use a series of natural, biologically driven mechanisms to treat and attenuate leachate chemical constituents with comparatively lower maintenance and energy needs than many modern treatment technologies but require larger allotments of land because of elevated residence time requirements. Researchers evaluated the effectiveness of the concept at the pilot-scale; this involved the completion of several pilot-scale experiments treating real, sampled leachate to measure the effectiveness of selected designs. The results of these experiments were promising as average concentrations of 508 mg L-1 NH3-N in leachate were removed by 53.7% after receiving only a fraction of the actual treatment that would be encountered at the full-scale; the system is designed to remove >98% of NH3-N and total nitrogen. Now the construction of a full-scale system permitted to treat up to 46,000 gallons per day of leachate is underway and set for completion in Fall 2024. This presentation details the design and evaluation process for this system and observations from early operations. The system is unique in that there are few constructed wetlands-based systems intended for the primary treatment of landfill leachate. It will utilize pre-treatment aeration and sedimentation ponds, vertical flow wetland cells, free water surface wetland cell, and zero-discharge industrial wastewater (IW) pond to reduce concentrations of leachate chemical constituents to acceptable water quality levels. The main constituent of concern is nitrogen, primarily in the form of ammonium, but the system is designed to treat organic matter, metals, and other constituents of landfill leachate.

Paper ID: 306

Feasibility assessment of municipal solid waste bottom ash in cement clinker production

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Abstract:
Municipal solid waste incineration (MSWI) bottom ash (BA) is produced through the process of waste combustion for energy generation and volume reduction. The BA consists of unburned MSW components which remain after incineration, and can be visibly identified as components such as glass, ceramic, concrete, slag, metals, and organics. MSWI BA contains quantities of Al, Ca, Fe, and Si which allow it to perform adequately as an additive in construction material, including as an ingredient in cement production, known as cement kiln feed. Some elements, such as chloride (Cl), exist in the BA and may limit its reuse capacities. Particularly, increased Cl content limits the reusability of MSWI BA as kiln feed, as Cl will volatilize and clog the ducts of the cement kiln. This study pretreats samples of MSWI BA via water washing at a pre-determined optimum liquid-to-solid ratio of 5 for 120 minutes to reduce total Cl in MSWI BA, and in BA which had been manually sorted into components of glass (Si), ceramic (Si, Al), concrete (Ca), and slag (Al, Fe). Finally, novel calculations were performed to determine the maximum replacement ratio of each MSWI BA type/component based on the elemental composition and limiting factors such as Cl. Washing MSWI BA removes total Cl at greater than 90% efficiency, and increases the acceptable BA replacement ratio in the kiln when utilizing washed ash instead of unwashed. Sorting and washing the BA components can further increase the replacement ratio; sorted components can be utilized to replace raw and mined materials such as limestone (Ca), iron ore, and sand/clay (Si) in the cement kiln. Washing MSWI BA to remove Cl increases beneficial use opportunities, potentially leading to decreased mining of virgin materials for cement production, landfill space savings, and reduced CO2 produced by the cement industry.

Paper ID: 307

Resource sustainability in the tourism industry: A critical review of waste generation and management considering the shift toward a circular economy

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Abstract:

Impacts on municipal solid waste generation and composition from the tourism industry are considerable, with tourism waste exceeding residential generation in some destinations. Tourists generate waste in the accommodation, food and beverage, transportation, and recreation sectors, and the influx of visitors often carries a high degree of seasonality, straining existing infrastructure for waste collection, treatment, and disposal. In this study, we examine waste generation and management in global tourism destinations to identify opportunities and challenges for applying circular economy principles. The review takes a three-step approach: 1) evaluate existing methods to quantify, characterize, and compare waste generated by tourists and residents, 2) classify current and proposed waste management strategies in tourism hotspots, and 3) assess existing policies to improve waste management and implement circular economy principles in the tourism industry. Waste composition and generation data from global case studies were compiled and normalized for comparison, and common trends among developed and developing countries were observed. Waste generation and composition data are frequently measured directly in developing regions, while the same data is estimated using socioeconomic and existing waste statistics in developed regions. Developing areas and island communities commonly visited by tourists often lack sufficient infrastructure and land area for effective waste management. The application of circular economy principles in the tourism industry has been found to reduce the amount of waste sent for treatment and disposal, while simultaneously improving environmental quality to attract future visitors and economic activity. Relevant stakeholders can use these findings to evaluate waste generation associated with local tourism and adopt policies promoting efficient resource use and environmental protection.

Paper ID: 308

The effect of various collectors and conditions on selective flotation of copper from copper, nickel, and cobalt sulfide matte

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Abstract:

Selective flotation condition for copper recovery from copper (Cu) – nickel (Ni) – cobalt (Co) sulfide matte was proposed in this work. In the conventional process, valuable metals of matte such as Cu, Ni, Co were recovered by hydrometallurgical process respectively, which has economic and environmental issues. For sustainable supply of valuable metals, flotation process is investigated to produce Cu concentrates and Ni-Co concentrates from the sulfide matte. Cu-Ni-Co sulfide matte was ground to 75μm as 80% passing size (P80) to prepare the flotation feed. Then, the chemical composition was: 22.1% Cu, 31.0% Ni, 3.93% Co, 6.27% Fe and others were almost sulfur. The objective of this research is to produce the two concentrates as Cu concentrates and Ni-Co concentrates (<3% Cu grade) from Cu-Ni-Co sulfide matte by flotation. In this study, the effect of various collectors and flotation conditions such as collector and frother dosage, air injection amount, pH, and conditioning time were investigated to the evaluate the efficiency of copper separation from Cu-Ni-Co sulfide matte. For selective copper separation, potassium amyl xanthate (PAX) was used as a collector, and around 90% of copper was recovered keeping 55% of nickel being depressed with the following conditions: 50 g/t of PAX without frother at pH 12.4. In addition, 1,3-diphenilguanidin (DPG) was used as collector, and when increasing the conditioning time from 5 min to 60 min, 50% of copper was recovered keeping 80% of nickel being depressed, with the following conditions: 150 g/t of DPG without frother at pH 12.4. Finally, each collector and test condition were evaluated and optimized for the selective flotation of copper from Cu-Ni-Co sulfide matte.

Paper ID: 310

A hierarchical circular supply chain management performance assessment: Improvement from firms' eco-innovation and technological performance

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Abstract:
This study assesses valid attributes and develops circular supply chain management performance (CSCMP) hierarchical structure for semiconductor industry. Prior studies are limited to synchronize technological performance and eco-innovation to enhance circular operation, financial benefits, environmental advantages and social benefits in the CSCMP. A data-driven approach combines qualitative and quantitative techniques, with a hybrid approach to form a hierarchical structure and determines the attributes ranks, providing decision-makers valuable insights and practical guidance. Data-driven approach incorporates content and bibliographic analyses, entropy weighted method, fuzzy Delphi method, exploratory factor analysis, fuzzy decision-making trial and evaluation laboratory and fuzzy analytic network process. The findings suggest stakeholders must collaborate to improve eco-innovation and technological performance to boost CSCMP. Decision makers must prioritize stakeholder engagement, risk and responsibility sharing, collaboration in the circular supply chain. In addition, service innovations and network innovation are also to enhance the circularity model.

Paper ID: 312

Comprehensive study on development of sustainable pavement quality concrete for rural road utilizing coal bottom ash

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Abstract:
Concrete pavements are standard in specific situations; nowadays, they are preferred for longer stretches. The pavement quality concrete (PQC) used in the construction of the pavement slab needs a massive quantity of fine aggregates, i.e. sand. The demand for sand is growing with the increased use of concrete in various infrastructure activities. PQC, as contrasted with regular concrete, is designed somewhat differently. The PQC used in concrete pavement aims to withstand repeated loading conditions under passing vehicles. The sand resources are being depleted year by year, and the availability of the right quality of sand in many locations is a significant concern with the very high cost of construction involving concrete. Many studies have been done to replace sand in PQC for concrete pavement. Coal bottom ash (CBA) is a waste material generated in massive quantities in many thermal-based power plants. This paper explores the use of CBA in replacing sand in PQC. An effort has been made to use CBA as a replacement for natural river sand for the M40 grade of PQC mix. Five mixes were selected with 0%, 25%, 50%, 75% and 100% CBA replacement levels for their mechanical strength. Additionally, their physical properties after 28 days of curing were studied. PQC mixes containing CBA were further investigated to understand their effect on the development of a sustainable concrete pavement. Results showed that the workability of PQC mixes was reduced with the CBA replacement level for the same water-cement ratio. At 7 and 28 days, PQC mixes containing CBA didn't develop significant gain in strength, but at 90 days, the mix containing 50% CBA satisfied the compressive and flexural strength requirements of M40 grade PQC. The PQC mixes containing further replacement levels failed to achieve the desired strength.

Paper ID: 315

Sustainable resource management towards circular supply chain in dairy industry in Vietnam: A causal interdependence approach

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Abstract:

This research contributes to inspect the interdependence relationships among circular supply chain (CSC) attributes towards sustainable resource management and advise practical suggestions for the dairy sector in Vietnam. Despite the contribution to human life and the economics, the dairy industry arises from serious pressings such as high levels of waste, water use and greenhouse gas emissions, resource scarcity, finite resources dependence, rising costs of raw materials and supply chain vulnerability. In this scenario, adopting CSC significantly benefit the dairy industry to decrease such problems and develop towards the target of sustainability. However, the main issue with circularity is the scarcity of resources, which significantly threatens ecosystems. Different resources and activities, including toxic chemicals, radioactive waste, and industrial hazards, can directly jeopardize human health and safety. Given this, prioritizing sustainable resource management (SRM) in CSC is crucial, as it can significantly reduce resource consumption and waste generation. To fill such gap, this research focuses on determining pivotal CSC and SRM attributes and their causal interrelationships. Since previous works are deficient in ascertaining attributes with an inclusive standpoint over qualitative material, a compound method including the fuzzy Delphi method, the fuzzy decision-making trial and evaluation laboratory, and the analytical network process is employed. Based on the theoretical foundation on resource-based view, natural resource-based view, and stakeholder theory, there are five aspects and 22 criteria from are initially authenticated. As a result, the group of cause encompasses technology advancement, circular human resource strategy, and circular collaboration, whereas group of effect covers sustainable product stewardship and zero-waste practice. The critical criteria cover waste management facility, commitment of top management, strategic planning, agro-ecological symbiosis, and partnership.

Paper ID: 316

Recycling of polyester textile waste by alkaline hydrolysis under mild conditions

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Abstract:

The environmental impact of the textile industry is a significant concern, and recycling polyester waste remains a challenge. Chemical recycling can potentially produce materials of equal quality and value as those from virgin feedstock. Postconsumer 100% polyester textile waste was recycled through alkaline hydrolysis to recover polyethylene terephthalate (PET) monomers: terephthalic acid (TPA) and ethylene glycol (EG). Various parameters were studied: base type and concentration (NaOH or KOH, 5-20%wt.), co-solvent fraction (ethanol, 0-40%v/v), sample size (1 cm² pieces or <4 mm dust), and reaction time (15-90 minutes). The reaction was conducted in a 500 mL three-neck glass flask with a magnetic hotplate stirrer. The solution (300 mL of water with the base and co-solvent) was stirred and heated to 90°C (without ethanol) or 80°C (with ethanol) before adding 3 g of washed, oven-dried sample (24 hours at 105°C). Hydrolysis was performed and then terminated by cooling the reactor in an ice bath. Unreacted PET was separated by vacuum filtration using glass microfiber filters. The solids were washed, dried, and weighed to determine PET degradation. The solution was acidified with H2SO4 to precipitate TPA, which was recovered by filtration using cellulose nitrate membrane filters. The liquid phase, containing EG, was stored for further analysis. Both solid and liquid products were analyzed by spectroscopic techniques to confirm reaction progress and product purity. The process achieved 94% PET degradation and 87% TPA yield by treating the sample at 80°C for 45 minutes with 40% v/v ethanol and 10%wt. NaOH. Results indicated that increasing NaOH and ethanol concentrations improved reaction efficiency up to a point, beyond which Na_2SO_4 precipitates and contaminates the TPA. Sample size had minimal impact, while longer reaction times did not significantly enhance results.

Paper ID: 317

Depolymerization of difficult-to-recycle PET waste using solvents in an alkaline medium

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Abstract:

The difficult recycling of single-use plastics is one of the biggest problems in managing urban solid waste. One example is polyethylene terephthalate (PET), used in most food and beverage containers. Depolymerization of PET can produce starting materials with the same quality and value as those of virgin materials. These starting materials are suitable for PET remanufacturing or other uses. Opaque green PET waste from post-consumer soft drink bottles was recycled by alkaline hydrolysis to recover the polyethylene terephthalate monomers: terephthalic acid (TPA) and ethylene glycol (EG). Several preliminary studies were carried out based on published literature, in order to decide the best parameters of the operating variables. A four-variable central composition experiment design was then performed with three levels, with different combinations of temperature (100, 80, and 60 ºC), time (90, 60, and 30 minutes), ethanol concentration (80, 60, and 40 % by weight) and KOH/PET ratio (3, 2, and 1 molar ratio). A total of 27 experiments were performed combining the values of the operating variables to compare the degree of depolymerization based on the values of the operating variables. Depolymerization was carried out in a 100 mL TFM vessel of a FlexiWAVE (Milestone) microwave, a microwave digestion system with a perfect integration between microwave equipment, reaction sensors, and pressure vessels. Through its control terminal with dedicated software, it provides control of the reaction parameters, as well as monitoring and recording of the entire depolymerization process. The PET that did not react was separated by filtration. The solution was acidified with HCl to precipitate TPA. A TPA yield of 86% was achieved for the experiment at 100 ºC, 90 minutes, 80% ethanol, and a KOH/PET ratio of 1. Temperature was the most influential variable, followed by ethanol concentration.

Paper ID: 320

Carbon footprint assessment and emission reduction strategies in urban drinking water infrastructure

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Abstract:

Water sector is one of the most significant contributors to global greenhouse gas emissions, with energy-intensive water supply infrastructure playing a major role. However, a comprehensive assessment of the carbon footprint across the entire urban water supply is currently lacking, hindering the development of effective emissions reduction strategies. This study aims to quantify the carbon footprint of the drinking water production process and identify opportunities for emissions mitigation in urban water infrastructure. Using Hong Kong as a case study, the research investigates the carbon emissions associated with water abstraction, treatment, and distribution by analyzing scope one (direct emission), scope two (indirect emission), and scope three (value chain emission). The results show that over 60% of the total carbon footprint is attributed to scope two emissions, primarily from electricity consumption by pumping operations. Other contributors include chemical usage in water treatment and fossil fuel consumption. The study reveals several promising emissions reduction strategies, including optimizing pumping schemes, integrating renewable energy, improving chemical management, and establishing a comprehensive carbon monitoring platform. This research provides valuable insights into the carbon hotspots within water supply infrastructure and offers a roadmap for water utilities to enhance their carbon management practices, thereby supporting low-carbon transitions in the urban water sector.

Paper ID: 322

Carbon emission reduction potential of nature-based solutions on upgrading wastewater treatment plants in China: A comparative study of advanced treatment processes and constructed wetlands

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Abstract:

Wastewater treatment plants (WWTPs) are required to upgrade to meet increasingly stringent effluent quality standards. However, the associated increase in greenhouse gas (GHG) emissions is overlooked. A comprehensive assessment of GHG emissions from different upgrading processes is critical for the sustainable development of the wastewater treatment industry. In this study, the life cycle assessment (LCA) model was used to evaluate the GHG emissions from common advanced treatment processes and constructed wetlands (CWs) as a nature-based solution across 4,179 WWTPs in 31 provinces of China. Our results revealed that the GHG emissions ranged from 0.14 to 0.43 kg of carbon dioxide equivalent (CO2eq) per cubic meter of treated wastewater. The carbon emission intensity of CWs showed a high spatial difference across provinces, influenced by local climatic conditions. The total GHG emissions from upgrading WWTPs ranged from 18.2 to 54.9 Gg CO2eq/d. Compared to advanced treatment processes, vertical subsurface flow constructed wetlands significantly reduced carbon emissions by 33.8% to 66.9%, while horizontal subsurface flow constructed wetlands resulted in higher carbon emissions. Optimizing energy structures could effectively mitigate GHG emissions, making advanced treatment processes more feasible than CWs by 2060. Our work highlighted the advantages of CWs in reducing carbon emissions and utilizing green energy and environmentally friendly construction materials are crucial for minimizing GHG emissions during WWTP upgrades.

Paper ID: 325

Reusing smartphones in sustainable building automation: A life cycle assessment

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Abstract:
The building sector is responsible for approximately 36% of global CO2 emissions and 40% of final energy consumption in the European Union, significantly impacting resource consumption, waste generation, and carbon emissions. These activities contribute to various environmental impacts, including acidification, climate change, eco- and human toxicity, and water and land use. While digital transformation and intelligent building energy systems can enhance energy efficiency, producing and transporting new digital equipment can increase resource consumption and emissions, potentially negating these benefits. Environmentally sustainable buildings require circular strategies focusing on reducing, reusing, recycling, and recovering resources throughout the building lifecycle. In previous research, we could demonstrate the technical feasibility of replacing Programmable Logic Controllers (PLCs) with discarded smartphones. This study addresses the research question: What are the environmental impacts of reusing discarded smartphones compared to traditional PLCs in building automation? We conducted a static Life Cycle Assessment (LCA) using the Ecoinvent v3.10 database and openLCA software, employing the ReCiPe 2016 midpoint (H) method to evaluate various environmental impact categories. The results indicate that reusing smartphones can significantly reduce environmental impacts compared to conventional PLCs, with the highest reductions in toxicological stress on human health and freshwater eutrophication by 69% and 68%, respectively. Electricity consumption is the primary contributor to environmental impacts across all categories, driven by high energy demands during production and use phases, particularly from coal-based electricity generation. Reducing electricity consumption and transitioning to greener energy sources are crucial for mitigating these effects. This research is significant as it is the first to explore the reuse of smartphones in building automation and provides a robust assessment of the environmental benefits of reuse strategies between the IT and building sectors. Future research will replace the assumed parameters with directly collected data by practically comparing PLCs with reused smartphones in the Empa NEST building.

Paper ID: 326

Water competition between food and energy production in china: a high spatiotemporal resolution analysis

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Abstract:

Quantifying water competition and its driving factors among major sectors is essential for integrated water resources management, particularly as seasonal variability in water availability exacerbates such competition. This study proposes a novel water competition index (WCI) to quantify the water competition between food and energy production (including water use by irrigation, coal mining, coke production, and thermal power generation). WCI provides monthly data for 2000, 2010, 2015 and 2019 across 1272 catchments in China. LMDI decomposition is further conducted to distinguish the contribution of activity level increase and water efficiency improvement to changes in WCI. The results reveal that: (1) The competition expanded from 2000 to 2015, and then subsequently declined. Approximately 10% of catchments (about 100) have WCI value above 0.1, with around 80% of these in high water stress basins (mainly in the Yellow River Basin and the Hai River Basin), which exacerbating water competition risks. (2) The higher WCI levels occur from March to June due to intensive irrigation in this season, even in water-abundant regions, such as Yunnan province in the Southwestern Rivers. (3) Thermal power generation is the primary driver of increased WCI, representing over 100%, followed by coal mining activities at over 28%. Water efficiency improvement in thermal power generation is the main factor reducing WCI, accounting for more than 80% of the decline, while changes in irrigation water efficiency have little contribution.

Paper ID: 327

The assistance of geophysical exploration for the sustainable management of resources

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Abstract:
Geophysical exploration technology plays an essential role in the facilitation of sustainable management of resources. Firstly, the utilization of advanced geophysical exploration techniques enables the precise detection and characterization of diverse subsurface resources such as oil, gas, and various minerals. This enhanced capability in pinpointing locations significantly diminishes the ambiguities and uncertainties inherent in traditional exploration methods, thereby reducing environmental harm and potential ecological repercussions effectively. Secondly, the employment of geophysical exploration methods facilitates a more thorough and intricate monitoring and evaluation of current resource reservoirs. Consequently, this approach ensures the rational and efficient exploitation and utilization of resources, preventing resource wastage and excessive extraction, promoting the sustainable utilization of resources. Moreover, as geophysical exploration technology continues to advance and innovate, it exhibits substantial potential in the exploration and exploitation of renewable resource sources. For instance, the investigation and utilization of geothermal and hydroelectric resources offer alternatives to conventional fossil fuels, aiding in the reduction of greenhouse gas emissions and the mitigation of climate change. The advancement in geophysical exploration technology not only enhances the efficacy of renewable resource development but also broadens the application spectrum of renewable resource sources, furnishing robust technical backing for the enhancement and restructuring of the resource framework. In conclusion, the application of geophysical exploration technology holds paramount importance in achieving a consistent and enduring resource supply. It furnishes the resource sector with empirical data and dependable technical support to assist policymakers in formulating more astute and sustainable resource management strategies. Through these methodologies, the anticipation and regulation of resource demand, optimization of resource dissemination, and assurance of uninterrupted and secure resource provision are significantly enhanced. This endeavor not only bolsters stable economic progression but also establishes a firm groundwork for the realization of global sustainable resource management objectives.

Paper ID: 328

Bulk materials on the transition to net-zero emissions: analysis of opportunities for including resource and infrastructure requirements in the National Energy and Climate Plans (NECPs)

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Abstract:
National Energy and Climate Plans (NECPs) are a policy instrument in European Union to inform energy policy on the transition to net zero greenhouse gas emissions. In the NECPs, EU Member States provide detailed information on current energy and climate policies and plans for the next decade. The reporting covers the dimensions “decarbonization” and “energy efficiency”. Steel and cement production are the two largest contributors to industrial GHG emissions in Europe and present technical challenges as their net-zero production requires novel process routes (e.g., increased recycling) and additional infrastructure (e.g., CCS and hydrogen). Publications by Creutzig et al. (2024) and Watari et al. (2023) outline the need for material demand reduction strategies to reduce material demand and accelerate infrastructure deployment to achieve net zero emissions. Current NECPs barely cover strategies to reduce emissions from bulk material production and (potential) resource limitations. Therefore, this contribution addresses the question: How can the reporting of resource and infrastructure requirements for bulk material production processes be improved in the NECPs? The question is addressed through an analysis of five NECPs, sixteen expert interviews and a structured review of publications on net zero emissions in the steel and cement production. Based on the analysis, a proposal for addressing infrastructure and resource requirements in the reporting framework is developed, using Germany as an example. The results show that measures for the provision of resources and infrastructure for the bulk materials are hardly covered in the NECPs despite measures at national level that contribute to the overarching goal. This provides an opportunity improve the reporting on policies related to net-zero pathways for bulk material production processes. Specific examples of a more detailed reporting for steel and cement production are presented and discussed based on the proposed reporting framework and the interviews.

Paper ID: 329

Trend analysis of climate variables– A case of Mbaka catchment in lake Nyasa basin

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Abstract:
The potential impact of climate change is now a common concern for governments, societies, and scientific communities. Climate change is one of the most potential concerns in the field of sustainable development whereby its impacts are felt in many parts of the globe. This study assessed the trend of climate variables (rainfall and temperature) from the Mbaka catchment in the Lake Nyasa basin from 1990 to 2023. The Mann-Kendall (MK) test was performed from the ten stations within the catchment to identify trends and magnitude of both annual and seasonal rainfall and temperature both maximum and minimum. Generally, the study has revealed both significant and non-significant increases in annual rainfall with most of the stations showing a non-significant increase in annual rainfall. There has been a non-significant increase in rainfall for the season of NDJFMA as per the results from most of the stations. The MAM season has been shown to have a significant increase in rainfall resulting from floods that occur almost every year during this season. The OND season has mixed results with the majority of the stations indicating a non-significant increase in rainfall while others have a significant decrease in rainfall. For the temperature results, the annual temperature for both maximum and minimum temperatures have increased significantly by 0.032°C and 0.048°C respectively. Seasonal temperatures have been shown to increase significantly for most of the stations as well as for both maximum and minimum temperatures. The changes in precipitation and temperature patterns identified in this study could have serious consequences for water resources, ecosystems, and the livelihoods of local communities dependent on agriculture and natural resources in the Mbaka catchment. The findings from this catchment-level analysis provide valuable insights to inform the development of targeted climate change adaptation and water resources management strategies.

Paper ID: 330

Water supply-demand index assessment for sustainable rice production in Upstream Watershed of Serayu Central Java Province Indonesia

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Abstract:
Water resources are essential for rice production, particularly in tropical and subtropical regions. The level of water availability about water needs indicates the level of food security. This study aims to assess the water supply demand index (WSDI) for sustainable rice production in a watershed scale under a tropical environment. Water supply ability was calculated from the river water discharge in the study site. A hydrologic tank model was used to estimate mid-monthly water discharge. While water demand for rice production was calculated using the Penman-Monteith method in CROPWAT 8.0. WSDI was classified into four categories, i.e., very poor (<0.49), poor (0.50-0.99), good (1.0-1.19) and very good (>1.2). The result showed that generally, the good category of WSDI was found in the study site for five years. The low value of WSDI was found during the dry season. Conservation strategies were needed to control water scarcity, especially during the dry season.

Paper ID: 331

"Circular Economy strategies in the Cement industry"

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Abstract:

Cement is widely used in construction and infrastructure. Global cement consumption is projected to exceed 5 billion tonnes by 2050. However, cement production consumes important quantities of fuel oil, energy, and raw materials and emits high amounts of CO2. Thus, this industry plays a crucial role in exploring energy/carbon-emission reduction strategies to address global warming and related climate change impacts. This study examines the impact of circular economy (CE) strategies on the cement industry's supply chain and production processes, including energy usage, raw materials consumption, and the associated costs of implementing these practices. Specifically, it investigates CEMII and CEMIII, types of cement produced by recycling industrial by-products such as fly ash and slag, as CE strategies to substitute clinker and reduce energy use. Additionally, the recycling of end-of-life (EoL) concrete in cement production is explored as a closed-loop supply system. The study's results, verified through interviews with cement stakeholders and analysis of technical and industrial reports, show energy savings for CEMIII and EoL concrete recycling, while CEMII requires more energy. All three strategies demonstrate significant raw material savings, particularly in sand and limestone. However, adopting CE strategies in the cement industry requires significant modifications to the supply system and production processes, due to new activities, such as preparing EoL concrete for use as raw material, different inputs, outputs, and costs.

Paper ID: 332

Thermal landfill leachate evaporation: How do per- and polyfluoroalkyl (PFAS) mobilize in this emerging leachate treatment technology?

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Abstract:

Per- and polyfluoroalkyl substances (PFAS) are applied to disposable consumer products, causing municipal solid waste (MSW) landfills to passively receive wastes containing the persistent chemicals. PFAS mobilize from waste through a combination of leaching, biotic, and abiotic degradation processes, and have been measured in landfill leachate (LL) and landfill gas (LFG) – two byproducts of landfill operation. Typical management strategies for LL and LFG do not effectively remediate PFAS, causing emission to the environment. Thermal evaporation systems are an alternative strategy which allow for onsite LL management, while discharging vapor as “treated” water and recirculating evaporation residuals to the landfill. The authors found in this study’s first publication that most PFAS mass was retained in evaporation residuals, but 9-24% of the PFAS mass entering in feed leachate was released to the atmosphere with vapor on the sampling days (n=3). In the next phase of the study, soil samples surrounding the stack of the same active thermal LL evaporator system, as well as the LFG flare, were analyzed for 91 anionic PFAS via ultra high-performance liquid chromatography tandem mass spectrometry (UHPLC-MS/MS). The data indicate a difference in PFAS concentrations between soils collected within 45 m of the evaporator stack and control soil samples collected around the landfill perimeter, though the PFAS profiles suggest a higher proportion of the PFAS may have originated from the LFG flare. To elucidate the sources from which PFAS may deposit to soils, evaporator exhaust and LFG were sampled using an XAD-2 resin based approach developed for adsorption and analysis of 27 neutral PFAS using gas chromatography coupled to a high-resolution mass spectrometer (GC-HRMS). LFG showed greater diversity and concentrations of neutral PFAS than evaporator exhaust, supporting the hypothesis that LFG flaring may contribute greater local PFAS deposition than the LL evaporator system at this site.

Paper ID: 334

Anionic and neutral per- and polyfluoroalkyl substance (PFAS) fate in simulated municipal solid waste (MSW) reactors

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Abstract:

The lipo- and hydrophobic nature of per and polyfluoroalkyl substances (PFAS) paired with their high thermal and chemical stability has proliferated the ubiquitous application of this chemical class in modern consumer goods ranging from cookware and packaging to cosmetics and clothing. However, when PFAS-containing products reach end of life, these same properties limit degradation and have stemmed a growing issue of environmental pollution – the mitigation and management of which is largely shouldered by the solid waste sector. In the US, the primary management strategy for municipal solid waste (MSW) is landfilling, during which, PFAS and other constituents within the waste stream can mobilize into liquid (leachate) and gas byproducts over time. While the presence and behavior of PFAS in landfill leachate is fairly established and research is emerging on volatile PFAS in landfill gas, PFAS partitioning and potential transformation between the two byproduct streams is not well understood. The ability for certain “precursor” PFAS to transform into more persistent “terminal” forms within biologically-active systems is well documented, and many theorized transformation pathways suggest the formation of intermediate volatile PFAS, like fluorotelomer alcohols, from common waste products. But, due to the sheer size and constant flux of landfills, a system-based assessment of PFAS within landfills has not been feasible. To address this gap, two large-scale reactors were constructed, filled with MSW substrate, and operated anaerobically to simulate landfill conditions. The PFAS mass balance within reactors was assessed by determining the initial total extractable mass of PFAS within feed material and monitoring releases of non- and semi-volatile (anionic) PFAS in leachate and volatile (neutral) PFAS in gas generated by the reactors over time. These findings present the first known measurements of both volatile and non-volatile PFAS from a whole MSW landfill system and provide fundamental data on PFAS behavior during landfilling.

Paper ID: 335

Managing challenges associated with beneficial reuse of wastes and industrial byproducts in roadway construction

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Abstract:
Roadways are critical transportation infrastructure in a rapidly developing world; 40 million km of roadways will be constructed worldwide over the next 25 years, consuming approximately 15 billion metric tons of aggregate. At the same time the world disposes of over 2 billion metric tons of waste and industrial byproducts per year in landfills, left for no useful purpose. This creates a great opportunity to divert these materials away from land disposal toward a useful purpose while conserving natural resources and reducing our impact on the environment. Resource managers, transportation agencies, engineers, and road constructors continue to find ways to reuse wastes and industrial byproducts in roadway construction, but there are many challenges. Methods are well established for predicting and mitigating direct human exposure and potential environmental impacts associated with constructing roadways from waste materials. However, the unique and often highly variable physical properties of these materials make them more challenging to use in construction. As a result, transportation agencies and roadway constructors are reluctant to use many waste products in roadway construction, which is a major impediment to significant adoption. This topic will focus on the challenges associated with building the key structural support component of a roadway (road base) using two different materials that are primarily managed by landfilling: phosphogypsum (PG), a byproduct of phosphoric acid production, and municipal solid waste incinerator (MSWI) bottom ash. PG is a soluble and fine-grained material with physical properties not ideal for road base. MSWI bottom ash is a granular material with properties similar to aggregates commonly used in road base, but its strength properties (e.g., bearing ratio, resilient modulus) are sensitive to water content during construction. We discuss strategies that we have investigated to overcome these challenges, such as ageing and blending with other industrial byproducts or natural materials.

Paper ID: 336

Estimating carbon emissions in data centres: a comparison of top-down and bottom-up approaches

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Abstract:
Recent increases in energy demand from data centres are expected to lead to a rise in carbon emissions. As a result, several studies have emerged attempting to estimate carbon emissions from data centres and cloud computing, but challenges remain in accurately capturing these estimations within carbon accounting frameworks. Given the increasing focus on carbon emissions, various methods have been developed specifically to estimate emissions from high-energy sectors like data centres. One common method is the 'top-down' approach, which estimates emissions based on annual production and consumption data, categorising activities from a broad, macro perspective. Another approach is the 'bottom-up' or 'activity-based' method, which provides more detailed data by analysing specific activities. Amid growing pressure to minimize environmental impact, data centre companies have implemented diverse strategies aimed at reducing carbon emissions, highlighting the need for accurate estimation methods. This study aims to estimate the carbon emissions of data centres related to cloud services and products in Singapore as a case study using the bottom-up approach. Additionally, it compares the results derived from the bottom-up approach with those from the top-down approach, such as estimates provided by Defra in the UK and the USEPA in the USA. Preliminary results indicate that carbon emissions estimated through the bottom-up approach are significantly lower than those estimated through the top-down approach. While the top-down approach provides a broad overview of emissions across the entire data centre and ICT industry, the bottom-up approach offers more precise estimates by focusing on specific activities within the sector. This study offers a valuable estimate of carbon emissions grounded in the detailed analysis of specific activities within data centres in a defined region. The continuous refinement of methodologies to reduce carbon emissions in data centres and cloud computing is essential to achieving sustainability in the ICT sector.

Paper ID: 338

Impact of water-saving technology on carbon emissions from agricultural irrigation in China

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Abstract:
The application of water-saving irrigation technology in many regions has not resulted in an increase in agricultural irrigation carbon emissions. This study, using panel data from various provinces in China from 2010 to 2020, employs the Malmquist index and LMDI index for decomposition to measure the rebound effect of carbon emissions from agricultural irrigation due to water-saving irrigation technology and the expected agricultural carbon emissions. The results show that the carbon emission reduction brought by water-saving irrigation technology is 3.583 times the expected carbon reduction, indicating that the expected goal of reducing agricultural irrigation carbon emissions by using water-saving irrigation technology has been achieved. The unit irrigation water and carbon emissions are increased, but the total water volume is reduced, thereby achieving a reduction in irrigation carbon emissions. The improvement of water-saving technology and the expansion of water-saving scale have promoted the uniform reduction of carbon emissions. In the main grain irrigation producing areas and provinces, the use of water-saving irrigation technology has a more significant effect on reducing irrigation carbon emissions.

Paper ID: 339

Analyzing the environmental impact of composting livestock manure in south korea using life cycle assessment

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Abstract:
As the world pursues carbon neutrality, the livestock sector significantly contributes to greenhouse gases like methane and nitrous oxide, and emits ammonia, a precursor to fine particulate matter. In 2020, greenhouse gases from livestock manure recycling constituted 23.7% of total agricultural emissions, highlighting the need for environmental impact assessments of manure treatment methods. This study examines the environmental impacts of composting, which accounts for 75.3% of livestock manure recycling in South Korea and analyzes its effects on climate change and fine particulate matter formation. This study applied the Life Cycle Assessment (LCA) methodology to evaluate the environmental impacts of producing one bag (20 kg) of livestock manure compost. The results indicated a climate change impact of 4.647 kg CO2-eq, with electricity consumption responsible for 84.83% of emissions. Carbon dioxide was the largest contributor, making up 88.28% of the total. The impact on fine particulate matter formation was 0.039 kg PM2.5-eq, with 86.06% attributed to air emissions from microbial decomposition. Ammonia (NH3) was the primary contributor to fine particulate matter, accounting for 86.18% of these emissions. The study confirms that electricity consumption is the main contributor to climate change and ammonia is the primary cause of fine particulate matter formation in the composting process. This research provides a case study for assessing the environmental impacts of livestock manure compost production and can serve as a foundation for developing future policies and technologies to address climate change and fine particulate matter issues.

Paper ID: 342

Toward a comprehensive model of green adoption behavior. Unveiling the impact of perceived social responsibility and psychological benefits

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Abstract:
Resource depletion and environmental change have a significant negative impact on the natural ecosystem and human societies, making green adoption and environmental conservation crucial for both individuals and firms. Despite this importance, a comprehensive framework integrating the antecedents, mediators, and moderators of green adoption behavior has yet to be developed. This study addresses this gap by examining how personal traits (antecedents), environmental concern, green environmental attitude, greem environmental self-identity, and green customer value (mediators), influence green adoption behavior. The study also explore the moderating roles of perceived social responsibility and perceived psychological benefits. A research framework was developed based on an integration of 3M Model, Signalling Theory, Attitude-Behavior-Context Theory, Value-Belief-Norm Theory, and Social Identity Theory. A survey approach was adopted using Mturk online data collection platform and obtained 352 randomized respondents. SPSS22 and SmartPLS3 were adopted in data analysis. The study results show that personality trait play important roles in environmental concern, green environmental attitude, and green customer value. Moreover, these mediators strongly influence green adoption behavior. The study also found that perceived social responsibility and psychological benefits enhance the effects of green attitudes, self-identity, and customer value on green adoption. Since previous studies still rarely integrated relevant research constructs to explain the phenomenon of consumers' green adoption behavior, this study has filled the research gaps to embrace our understanding of antecedents, mediators, and moderators of green adoption behavior. The study results could be very supportive for academicians to conduct further validation on this research issue. The results could be also very helpful for executives and managers to design and implement appropriate green marketing and management strategies to pursue the sustainability development of the firm.

Paper ID: 343

Valorization of egg white from discarded eggs as additives for sustainable mudbrick manufacturing: A comprehensive technical and environmental evaluation

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Abstract:

This study evaluates the technical aspects, environmental impacts, and chemical compatibilities of incorporating discarded egg whites as reinforcing additives in sustainable mudbrick production. The experimental process involved mixing soil, tap water, varying percentages of egg white, and different neutralizing chemicals (H2SO4, CaSO4.2H2O, and C6H6) to create mudbrick specimens. Physical, mechanical, durability, and microscopic evaluations were conducted on the modified mudbricks, including assessments of compressive strength, dry density, water absorption, efflorescence, hardness, color, and microstructure. Additionally, a cradle-to-site life cycle assessment (LCA) compared the environmental performance of mudbricks with traditional fired bricks across 18 impact categories. The findings indicated that specimens SWE-7, SWEA-7, SWEG-7, and SWEB-7, containing 7% discarded egg whites, 7% water, and 7% acid, gypsum, or benzene, yielded highly favorable results. Compared to control samples, these modified bricks exhibited significantly improved strength, dry density, water absorption, efflorescence, and hardness properties. Furthermore, the bricks showed no significant reactions with the neutralizing chemicals, indicating their inertness to acidic or basic substances. The LCA analysis revealed that mudbricks had an average environmental impact nearly 98.87% lower than fired bricks across 18 impact categories. This suggests that the modified mudbricks hold promise for use in construction projects in both rural and urban areas, potentially replacing fired clay bricks and reducing CO2 emissions in the construction industry.

Paper ID: 345

Parametric BIM-based environmental and economic performance of high-strength steel grades in high-rise building designs

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Abstract:
High-strength steel (HSS) is gaining prominence in skyscraper construction due to its potential to reduce material usage, environmental impact, and cost. However, a comprehensive understanding of the economic and environmental performance of HSS grades in high-rise buildings is lacking, considering different design loads and floor configurations. This study addresses this gap using a parametric life cycle assessment (PLCA) model to identify the threshold at which HSS grades (S460, S500, S550, S620, and S690) become more viable than conventional steel. To evaluate environmental and economic impact, 18 impact categories (ICs) are systematically and semantically integrated into building information modeling (BIM) models as design parameters, incorporating geometry, material, and supplier information. The PLCA model dynamically calculates environmental and economic impacts and visualizes them in real-time bar charts within the BIM environment. Multi-objective optimization (MOO) optimizes weight, cost, energy use, and CO2 emissions while adhering to design constraints. The accuracy and flexibility of the PLCA model are validated by comparing it with a conventional life cycle assessment (LCA) on 8- and 20-storey case study buildings. Results demonstrate that 20-storey buildings constructed with HSS grades of S460, S500, S550, S620, and S690 achieve environmental impact reduction of 7.5%, 14.6%, 23.2%, 30%, and 38.9%, respectively, compared to mild steel. Furthermore, these HSS grades become cost-comparable to S355 when constructing 17-, 26-, 34-, 43-, and 65-storey buildings, respectively. The utilization of HSS presents an opportunity to decrease CO2 emissions and costs, contributing to the transition of the steel industry towards a "net-zero" future.

Paper ID: 348

Performance comparison of Ocean Thermal Energy Conversion(OTEC) plant performance for equatorial applications.

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Abstract:
This study analyzes the performance of a 50 kW Ocean Thermal Energy Conversion(OTEC) cycle for equatorial island countries. To compare the net power output, the diameter and length of the surface water and deep water pipes and their losses were obtained, and the height from the pump pit to the shore was reflected in the power requirement calculation. The performance of the cycle was compared for a total of five types of working fluids, including natural, HFC, and HFO. Among them, one working fluid was selected in consideration of environmental impact, cycle performance, and core component compatibility, and cycle optimization was performed for the selected operating fluid. The working fluids used for the comparison were ammonia, R32, R1234yf, R1233zd(E), R1234ze(E), and R1234ze(Z), of which R1234ze(Z) was selected as the optimal operating fluid and cycle optimization was performed for it. For performance comparison, the gross power of the turbine, surface water, deep water flow rate, and seawater pumping power were obtained, and the net power output for each working fluid was derived and compared. For the analysis, the turbine inlet temperature fixed at 24℃ and the working fluid flow rate for 50kW power generation were assumed, and the 50kW output of the cycle for each working fluid was derived through the turbine inlet pressure and outlet pressure in the operable range based on the working fluid temperature of 24℃. After the performance comparison, optimization was conducted to reduce the parasitic load for the selected working fluid.
- This research was supported by a grant from the Endowment Project of “Development of Eco-Friendly New Seawater Desalination-High Concentration Process” funded by the Korea Research Institute of Ships and Ocean Engineering (PES5173).

Paper ID: 353

Does urban growth boundaries control on rural communities development: Evidence from the uneven development of land in Wuhan,China

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Abstract:
Urban growth boundaries (UGB) are a useful tool for curbing urban expansion and increasing the efficiency with which territorial space is utilized, but the disparities in development opportunities between areas inside and outside of UGB might impact the regional uneven development. Clarifying UGB impact on uneven development is essential for a full comprehension of China's reform of territorial spatial planning and the realization of coordinated regional development. We use propensity score matching and the quantile regression approach to analyze the degree of effect and heterogeneity of UGB on the rural communities uneven development (RCUD) using 2,241 villages in the new urban area of Wuhan as an example. First, it is discovered that rural communities included in the UGB have better public service facilities(PSF), a higher stock of land assets(SLA), and a higher level of industrial development(LDI) after accounting for sample self-selection bias using propensity score matching. Second, is that the location enhances the impact of UGB on the RCUD. Specifically, the better the rural communities location, the higher the inhibitory impact between UGB and the quantity of primary and secondary industrial enterprises as well as the stock of homestead land assets. Similarly, the higher promotion impact between UGB and the quantity of third-industrial enterprises, PSF, and the stock of construction land assets. Finally, Quantile regression demonstrates that there is a Matthew effect—a "strong will always be strong, weak will always be weak"—and that the degree of UGB's impact on the RCUD increases with the village's resource endowment. Additionally, there is a threshold effect of UGB on the LDI. The study's findings not only respond to the practical requirements for strengthening territorial spatial planning reform, but they also offer a foundation for resolving the planning regulation-related problem in rural communities development.

Paper ID: 354

Assessment and application of carbon absorption in urban green environment

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Abstract:
Urban areas, responsible for nearly 70% of global CO2 emissions, are critical battlegrounds in the fight against climate change. These emissions predominantly arise from fossil fuel consumption in industrial processes, transportation, and the construction of carbon-intensive infrastructure. This dissertation investigates the potential of urban green spaces to absorb carbon, focusing on two distinct geographical contexts: Korea and France. The study encompasses a variety of urban green spaces, including residential gardens, public parks, street trees, and lawns, to develop a comprehensive understanding of their carbon absoprtion capabilities. To achieve this, the research employs a multi-faceted data collection strategy. High-resolution imagery is used alongside Google Maps and GIS data to capture detailed and accurate representations of urban green spaces. These data are then analyzed using RGB color analysis and machine learning algorithms to precisely categorize different types of vegetation and assess their carbon absorption potential. A robust data management system ensures that these diverse data sources are integrated consistently, facilitating reliable and comprehensive analysis. The expected outcomes of this research include the development of accurate models for carbon absorption across various urban green spaces and proposals for optimizing green space configurations to maximize carbon sequestration. These findings will provide evidence-based guidelines for urban planners and policymakers, supporting the design of greener, more sustainable cities. Moreover, the research aims to deepen our understanding of the role urban green spaces play in mitigating climate change, offering valuable insights into how urban environments can be made more resilient. By addressing challenges related to data accuracy, categorization complexity, and modeling intricacies, this study contributes to the development of practical solutions for enhancing carbon absorption in urban areas, ultimately aiding global efforts to combat climate change.

Paper ID: 355

Data based environmental evaluation model utilizing internet of things in agricultural product cultivation

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Abstract:
Agricultural products from farmlands are vital to our diet, but farmland environmental conditions, particularly air and soil pollution levels, can greatly affect crop quality and safety. Pollutant accumulation in crops poses health risks to consumers. This research aims to evaluate farmland environments in real-time during crop growth to ensure agricultural product safety. This study analyzes the effects of air and soil pollutants on crops and their potential health risks comprehensively. This research develops a real-time environmental information analysis device and evaluation indices. A device was created to monitor farmland conditions in real-time, featuring air pollutant sensors measuring PM2.5, NOx, SOx, and CO, a soil fertility meter for nitrogen, phosphorus, and potassium concentrations, a data logging system for cloud-based storage, and a visualization system with alerts. This device enables quick responses from agricultural workers and provides transparent information to consumers, building trust. This study developed four evaluation indices: Air Pollution Index (API), Soil Pollution Index (SPI), Soil Fertility Index (SFI), and Human Health Impact Assessment Index (HHIAP). These measure air pollutants, soil heavy metals and pesticides, soil nutrients, and assess health impacts through pollutant correlations. Combining these, the Overall Environmental Assessment Index (OEAI) was created. Data was collected from 10 Korean and 2 French farmlands, measuring air and soil pollutants in real-time for comprehensive environmental assessment. This study uniquely integrates air and soil pollution assessment with real-time data collection, providing consumers with crop growth environment information. It enhances agricultural product safety, consumer trust, and sustainable farming. Unlike traditional methods, it offers comprehensive environmental evaluation, allowing consumers to choose safer, healthier produce. This approach is considered innovative in agriculture.

Paper ID: 359

Estimation of soil organic carbon stock in Darjeeling using RothC model

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Abstract:
Due to the increasing of Atmospheric CO2 levels and global warming are causing growing concerns about the quality of soil due to organic carbon. Soil organic carbon is the balance of carbon input and output, and even a slight shift can have a significant effect on the global C cycle and atmospheric level of CO2. Field experiments requires a high cost therefore, simulation models are used widely for estimation SOC in long term run and as an important tool for decision making for future projected climatic conditions. Modelling quantifies SOC due to historical change in land use and climate, future change in land use and climate and different land management strategies. RothC model accounts for the influence of different types of soil, climate and plant covers on the turnover of SOC. Hence, RothC model has been applied in the sixty estates of Darjeeling district to quantify the SOC content and its C components for 2013-2020 and also for future projected climate change (2021-2030). Further, with the help of the plant C input data SOC stock was estimated for 2013-2030. Sensitivity analysis was also conducted for the climate change data of 10% and 30%. It was observed that for both analyses the C pools, SOC and CO2 increased annually and the increase in CO2 was more than SOC stored signifying the soil as C sink. The amount of SOC stored was more in 10% climate change analysis than for 30% climate change analysis. However, the CO2 emission was more for 30% climate change analysis than for 10% climate change analysis. This shows that climate change influences SOC stock and helps to identify if the soil could act as source or sink for the carbon.

Paper ID: 360

The influence of particle shape on the particle motion during jig pulsation and its reduction using modified water pulsation

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Abstract:

Jig separation is not only affected by the difference of particle density but also particle geometry (i.e., size and shape). In this study, the effects of particle shape on particle motion during water pulsation were investigated. Acrylonitrile butadiene styrene (ABS; specific gravity (SG) of 1.03) and polystyrene (PS; SG of 1.06) were prepared into cuboids with similar equivalent volume diameters but different particle shape. The motion during water pulsation was recorded using a video camera and analyzed by image analysis. Water pulsation during jig separation is comprised of 4 steps: (1) rising, (2) initial holding, (3) downwelling, and (4) final holding. The results showed that jig separation efficiency is strongly influenced by particle motion during step 1. Based on these results, modifications of water pulsation to reduce the effects of particle shape on jig separation efficiency could be proposed.

Paper ID: 361

The enhancement of microplastic removal via agglomeration-micro-flotation using UV-irradiation as a pretreatment

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Abstract:

Microplastics (MPs) are easily contaminating water bodies and posing significant risks to ecosystems and human health due to their size and hydrophobic surface. To remove MPs, flotation is suitable for the MPs removal using high hydrophobicity of MPs but due to the micro size of MPs the efficiency of flotation may not satisfy. To remove MPs, the agglomeration-micro-flotation (AMF)—a column flotation with kerosene as a bridging liquid—was proposed in this study to enhance the floatability by increasing particle sizes and decrease the bubble size. Furthermore, UV-irradiation pretreatment was also applied to modify the surface wettability of MPs prior to AMF. The result shows that UV-irradiation could enhance the surface wettability of MPs and enhance their removal rate via AMF.

Paper ID: 362

Sustainable biowaste based self-regenerative multifunctional superhydrophobic film

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Abstract:
Superhydrophobic materials with self-cleaning, anti-icing, and drag-reducing properties are highly desirable. However, their practical applications are hindered by poor durability and high production costs. This study addresses these challenges by developing an eco-friendly, non-fluorinated bulk superhydrophobic material using biowaste. Wheat straw (WS), a prevalent agricultural waste, poses significant environmental problems due to its slow decomposition and massive annual volume. This study thoroughly analyzed WS's thermal degradation to optimize its recycling process with minimal environmental impact. The air-spray approach was used in creating bulk superhydrophobic film by varying fractions of polydimethylsiloxane (PDMS) and nanoparticles (> 500 nm) synthesized from wheat straw. The optimized wheat straw-based composite maintained excellent superhydrophobicity (θ> 150o) and ultra-low adhesion (~10 μN) while offering additional sustainability benefits such as self-healing and self-regenerative capabilities under extreme conditions. The composite films also demonstrate ~77 % drag reduction and effective selective oil absorption, making them particularly promising for autonomous oil recovery systems in marine environments. These fluorine-free, flexible films offer a sustainable solution for managing wheat straw waste and exceptional properties that make them suitable for a wide range of applications. Their minimal drag and selective oil absorption capacity.
Keywords: Bulk Superhydrophobicity, fluorine-free, self-regeneration, self-healing, drag reduction, oil-water separation.

Paper ID: 364

Step-by-step guides on green infrastructure connectivity provision in kuala lumpur, malaysia

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Abstract:

Fragmentation of green spaces disrupts the natural ecosystem in urban areas. Hence, there is a need to study green infrastructure (GI) via ecological connectivity to solve this problem. As the rapid urbanisation in the capital city of Malaysia, Kuala Lumpur (KL), has instigated green space fragmentation, this study intends to develop GI using the landscape ecology principle, graph and circuit theories, and minimum cumulative resistance (MCR). Notably, tools such as ArcGIS, GuidosToolbox, Conefor, Linkage Mapper, and Circuitscape were duly incorporated. Possible GI sources were also systematically identified. Although the green spaces in KL were fragmented following the Morphological Spatial Pattern Analysis (MSPA) result, ecological connectivity was structural and functionally enhanced post-optimisation. Summarily, ecological connectivity could be strategically restored with multiple tools. The empirical approach and outcome could facilitate GI planning in tropical nations by integrating a systematic selection of GI elements.

Paper ID: 366

Assessing additional CO2 emissions caused by the propagation of drought risk through China's power sector

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Abstract:
China experienced a severe drought in the summer of 2022, which could have significant implications for hydropower-dependent electricity systems and the interconnected power sector. Utilizing monthly data of 31 provinces in China from 2010 to 2022, we examined the response relationship between runoff and hydropower generation, the substitution effect between thermal power and hydropower, the spillover effects within the electricity network, and the additional CO2 emissions induced by drought. Our findings reveal that: (1) Runoff' impact on hydropower generation exhibits a significant time-lag effect, non-linear characteristics, and interacts with the scale of hydropower capacity. (2) The local substitution effect between thermal power and hydropower is robust, with a coefficient of -0.278, and both upstream and downstream spillover effects are negative, significant but asymmetrical. (3) The reduction in hydropower output is estimated to be 165.7 (±62.0) TWh, leading to an increase in thermal power output by 68.1 (±24.4) TWh and corresponding CO2 emissions of 54.98 (±19.95) million tonnes. (4) Drought spillover risk is approximately three times more severe for downstream provinces than upstream ones. This analysis highlights the critical pathways through which drought influences the water-electricity-carbon nexus in China.

Paper ID: 369

From Ratings to Reality: ESG's Influence on Corporate Misconduct and Rater Disagreement in the Construction Industry

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Abstract:
Environmental, Social, and Governance (ESG) criteria, increasingly recognized for their importance, are standards used by investors to evaluate a company's ethical impact and sustainability. This study examines the relationship between Environmental, Social, and Governance (ESG) ratings and corporate misconduct within the construction industry, exploring the predictive power of ESG metrics and the impact of rating discrepancies. Corporate misconduct, often resulting from breaches of legal or ethical standards, presents a significant challenge in the construction sector due to its complex operational environment and susceptibility to corruption. ESG ratings, which evaluate a firm's commitment to sustainable and responsible business practices, have emerged as crucial tools in assessing corporate behavior and risk management. This study hypothesizes that higher ESG ratings correlate with reduced instances of corporate misconduct. However, the relationship is complicated by discrepancies between different rating agencies, which may lead to investor confusion and impact the predictive accuracy of ESG scores. Our research further hypothesizes that the level of disagreement among ESG raters negatively moderates the relationship between ESG ratings and misconduct, potentially obscuring the true nature of corporate activities. Utilizing a robust dataset from China's construction industry, this paper employs regression analysis to test these hypotheses. Our findings indicate a complex interplay between ESG ratings, rater disagreements, and corporate misconduct. While ESG ratings generally align with lower misconduct rates, the inconsistencies between ratings from different agencies introduce noise that affects their reliability as predictors. This research underscores the need for standardized ESG assessment methodologies to improve transparency and effectiveness. The results indicate that firms with better ESG performance can reduce misconduct risk, but stakeholders must consider rating discrepancies. By clarifying ESG's role in promoting ethical business practices, this study provides valuable insights for policymakers, investors, and corporate leaders seeking to foster sustainable development in the construction industry.

Paper ID: 372

VR-based training system for welding safety training

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Abstract:
Welding is a critical but hazardous occupation that necessitates comprehensive safety training to prevent accidents and ensure workplace safety. Traditional training methods often fall short in providing the immersive, hands-on experiences required to adequately prepare welders for real-world challenges. This paper investigates the application of Virtual Reality (VR) technology in welder safety training, emphasizing the use of constructivist learning theory in the design of VR training scenarios. Constructivism, which posits that learners build knowledge through active engagement and experiential learning, is particularly well-suited to VR environments where trainees can interact with realistic, simulated welding tasks and safety protocols. The study explores how constructivist principles can enhance the effectiveness of VR training by facilitating deeper learning, improved knowledge retention, and the practical application of safety measures. Additionally, the paper examines the sustainability benefits of VR, such as reducing material waste and providing reusable, scalable training resources. By minimizing the need for physical materials and setups, VR emerges as both an effective training tool and a means to support environmental sustainability. The expected results from case studies indicate that VR-based training, when designed with constructivist principles, significantly enhances safety awareness and preparedness compared to traditional methods. The paper concludes that integrating VR into vocational training, underpinned by constructivist learning theory, not only improves the quality and safety of welder training but also aligns with modern sustainability practices, offering a forward-looking approach to vocational education.

Paper ID: 376

Evaluating the potential for resource recycling efficiency in urban municipal solid waste management in China.

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Abstract:
As waste sorting becomes mandatory in China, the country is shifting from a focus on final disposal to a more diversified approach to municipal waste management, emphasizing the reuse of waste as a valuable resource. This study examines the municipal waste supply structure in major Chinese cities, focusing on the role of recycling. By evaluating the material metabolism of the recycling system and applying material flow analysis, the study developed a model to quantitatively assess the circulation of municipal waste. The findings reveal patterns in resource recycling and the evolution of in-use stock. The material metabolism model, based on social circulation, used material flow-life cycle assessment to measure key indicators such as recycling and reuse rates. These insights provide valuable guidance for the transformation and improvement of related industries. However, the research also identifies persistent challenges in China's waste recycling system, such as low resource productivity, low recycling rates, and inadequate recycling levels. Adjustments in industrial and product structures, coupled with technological advancements, have significantly affected the material metabolism of waste, with reduction technologies having a particularly important impact.
Keywords: municipal solid waste; recycling; material flow analysis; life cycle assessment

Paper ID: 377

Enhancing stochastic frontier models: a Bayesian approach to multimodal error distributions

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Abstract:
The stochastic frontier (SF) model is an effective tool for measuring carbon emission efficiency. In traditional SF models, the composite error term is modeled as the sum of inefficiency and idiosyncratic terms, with maximum likelihood estimation (MLE) employed to estimate regression coefficients based on a specified inefficiency distribution. However, these models do not account for the potential multimodal distribution of the inefficiency or the composite error term. To address these limitations, we propose a novel hierarchical Bayesian prior structure on the composite error term to infer the posterior distribution of inefficiency through Hamiltonian Monte Carlo (HMC). Specifically, assuming a normal distribution for the idiosyncratic term, we introduce a hierarchical Bayesian prior structure based on a mixture of Student-t distributions to model the composite error term, leveraging its heavy-tailed characteristics and mixture method to capture multimodality. Given the relatively high-dimensional parameters in this hierarchical Bayesian structure, we effectively derive the posterior distribution of the composite error term using HMC. The posterior distribution of inefficiency is subsequently inferred by subtracting the normal idiosyncratic term. We validate our approach using China's provincial carbon emission input-output panel data, employing the Translog production function for its flexibility within the SF model. The feasibility of our approach is assessed through convergence diagnostics, while its performance is evaluated by comparing posterior means with MLE estimates of coefficients in the Translog production function. The empirical results demonstrate that the posterior mean closely aligns with MLE estimates, particularly when the idiosyncratic term shows good convergence. The bimodal characteristic of inefficiency is captured. Consequently, our approach offers consistent and more informative estimates for the posterior analysis of stochastic frontier models, independent of specific inefficiency distribution assumptions.

Paper ID: 380

LCA to estimate CO2 emissions related to the installation of a solar photovoltaic system

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Abstract:
Due to Brazil's geographic location, the country is promising for generating energy from renewable sources. With high levels of solar irradiation, the use of photovoltaic (PV) solar has grown in recent years, and the perspective is that installations will increase for this alternative. With the current global warming scenario and its worsening perspective, it is interesting to assess the lifecycle GHG emissions related to installing PV systems, thus studying possibilities for reducing the carbon footprint of this promising energy generation alternative. This work evaluates the carbon footprint of a rooftop PV system with 290.16 kW and 496 modules installed at the University of São Paulo, Brazil. The system boundary of the LCA ranges from manufacturing to installation of PV modules and BOS, including import, transportation, labor, packaging, and energy. We have gathered data from the Environmental Product Declaration (EPDs) and the monitoring of PV system installation. The functional unit is 1 kWh of electricity generated from the solar photovoltaic plant. Although the BOS is responsible for a small share of the lifecycle emissions, It is possible to define the main processes responsible for GHG emissions and suggest design alternatives to reduce them with the results of this study.

Paper ID: 381

The Circular Economy of WEEE in Hong Kong: MFA, LCA and future prospects for circular management

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Abstract:
In the Hong Kong Special Administrative Region, the rapid annual growth (2%) of waste electrical and electronic equipment (WEEE) constitutes a threat and opportunity for locally driven climate change: While collection, transportation, and treatment entail emissions and thus bear global warming potential, adopting circular economy strategies (reuse, repair, refurbishment, recycling, etc.) can instead yield a climate positive impact. To assess the dimension of these realities, this study is the first of its kind to combine material flow analysis and life cycle analysis for a circular economy approach on WEEE in Hong Kong. For these assessments, individually collected, hitherto novel data from (1) two household surveys in Hong Kong and (2) semi-formal e-waste repair and trade shops will be used. Our findings show that around 144,000 tonnes (19.23 kg/cap/y) of WEEE (air-conditioner, refrigerator, washing machine, television, monitor, laptop, mobile phone, tablet, printer and scanner) are annually generated by households in Hong Kong. Interviews with informal repair and trade practitioners showed that most of the WEEE is exported as refurbished second-hand products. Of the four WEEE management options considered, the best option in terms of potential climate impact is repair followed by reuse and recycling while export is the least favourable option. In conclusion, we evaluate a prospective scenario for circular management of WEEE in Hong Kong: Due to the tightening global WEEE export controls and declining demand for secondary WEEE in outside markets, the current export reliance will not be sustainable over the long term. Therefore, a prospective scenario analysis for different circular economy approach will be applied to predict future WEEE reduction and CO2 mitigation. Doing so will provide recommendations on how future policies and management should be developed to achieve a circular, sustainable WEEE management system in Hong Kong.

Paper ID: 383

Modification of silica precipitation filterability by ionic and nanoform silica

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Abstract:
In Zinc wet smelting process, problems related to decreased filtration speed by silica gel are occurring. When roasted zinc concentrate (calcine) is leached by sulfuric acid, silica gel is formed by a polymerization reaction of silicate that dissolves with the zinc ion. This silica gel clogs the filters and causes zinc production to be less efficient. To solve this problem, this experiment explored the conditions under which easily filtered silica precipitates are formed by preparing precipitates using silica in different initial states and evaluating their filterability. In this experiment, 1 g/L of coexisting elements such as iron and aluminum in the zinc leach solution was added to a solution prepared with 1 g/L or 4 g/L of silica of different particle sizes (ion, 12 nm, 45 nm, 80 nm). They were allowed to stand in an incubator at 80°C for 3 hours to allow the solution to precipitate completely. After that, these samples were filtered. The time taken for filtration was measured and recorded. As a result, filtration time decreased as the particle size of the added silica increased. These results indicate that silica precipitates, which are difficult to filter, are formed under the influence of small particle size silica and coexisting elements such as iron. It is thought that the colloidal silica with a large particle size acted like a seed crystal, forming a precipitate of particles of a size that is easier to filter than silica gel. These results indicate that silica precipitates, which are difficult to filter, are formed under the influence of small particle size silica and coexisting elements such as iron.

Paper ID: 385

Optimization of China's wind-power and PV development pathways considering the availability of metal resources

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Abstract:
Large-scale deployments of wind-power and PV are expected to achieve China's long-term climate targets. However, the metal requirements of deploying wind-power and PV are simultaneously projected to surge multifold. Incorporating metal resource constraints into energy system planning is essential to analyze and handle such material challenges. This study constructs an optimization model to minimize the metal requirements of China's energy development pathways while achieving the carbon neutrality goals. It is found that the optimal pathways show the characteristics of "first slow then fast" after considering the availability of metal resources. The metal conservation effect is less significant in wind power than for PV. Via optimization, the cumulative Ag requirement of PV can be reduced by 11-15%, while the cumulative Cu requirement of PV is reduced 8%. In contrast, cumulative Dy and Cu requirements of wind power deceased by only 3.4% and 3.5% after optimization. We suggest implementation of both supply- and demand-side coping strategies to secure the material basis of low-carbon technology deployments. We also highlight that missing information and uncertainties in metal supply and demand in the energy sector of Integrated Assessment Models (IAMs) could threaten the realization of decarbonization scenarios. Shaping energy-metal relationship in IAMs requires the deep collaboration of the researchers across different resources planning and management systems.

Paper ID: 388

Comprehensive benefit evaluation of carbon reduction and renovation model for existing residential facades based on the whole life cycle: a case study of Shenzhen

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Abstract:

Urban housing is the main source of carbon emissions. In the era of stock housing, the renovation of old residential areas, as an important part of urban renewal, has an important impact on reducing energy consumption and carbon emissions. In the current research on existing residential buildings, most of the research focuses on energy-saving renovation measures for single buildings. This study conducts a full life cycle assessment of different facade renovation schemes in the renovation of old residential areas, taking into account energy consumption, carbon emissions and economic costs. Taking the actual case of the renovation of old residential areas, the renovation case of Songping Village in Shenzhen, as a reference, two wall and window renovation schemes were compared and evaluated, and the energy-saving and economic performance of different renovation schemes were compared. The energy-saving and economic performance of different renovation schemes were compared. The results show that the renovation of old residential areas is conducive to building energy conservation, carbon reduction and cost saving. Compared with before the renovation, energy consumption and carbon emissions were optimized by 34% -49%. Among the renovation measures, the energy consumption and carbon emissions of only renovating the exterior windows are the lowest, and it is also the most effective cost-saving measure. After the facade renovation, the cost can be saved by 2.60-3.83 million yuan per year during the construction period. This study can guide the low-carbon energy-saving renovation of old residential areas and help to comply with the national trend of energy conservation and emission reduction.

Paper ID: 389

Optimizing Thailand's regulatory framework for solar deployment and land use management

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Abstract:
Thailand's urban and energy planning has historically been centralized. Decisions regarding land use and power generation were primarily made at the national level, limiting local agency in both domains. While the Department of Public Works and Town and Country Planning (DPT) introduced a more consultative land use planning process in 2002, local governments retained limited authority in plan development. Similarly, the Energy Policy and Planning Office's (EPPO) centralized power development plan emphasizes national generation capacity while requiring an environmental impact assessment with community engagement and public hearings prior to power plant development and construction in that site. Recent decreases in solar module costs and the Thai government’s ambitious climate targets highlight the increasing importance of solar energy. Given Thailand’s high solar potential and its goal of achieving carbon neutrality, the future energy system will need to incorporate a significant proportion of solar power. As solar projects are likely to expand onto agricultural land, considerations include the balance between energy generation and agricultural land use, as well as potential opportunities for income diversification. The study conducts a cost-benefit analysis to evaluate the feasibility of converting agricultural land into solar power plants. It examines the trade-offs between energy generation and agricultural production, considering factors such as income diversification potential. Additionally, the research proposes a regulatory framework for solar deployment and land use management to optimize the integration of solar energy into the agricultural landscape.

Paper ID: 390

Cascading effects of mechanization on agricultural carbon productivity

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Abstract:
Carbon emissions, a key driver of global climate change, pose significant threats to agricultural production. China, responsible for about one-third of global CO2 emissions, is in a crucial period of transitioning from traditional to modern agriculture. The Chinese government is committed to achieving its “double carbon” targets by integrating food security, emission reduction, and carbon sequestration goals, alongside promoting green and energy-saving agricultural practices. Improving agricultural carbon productivity is vital to mitigating the effects of climate change and achieving these goals. However, existing research has largely ignored the role of agricultural mechanization in this context. This study addresses this gap by examining the cascading impacts of mechanization on agricultural carbon productivity across Chinese provinces using inter-provincial panel data from 1997-2019 and an expanded STIRPAT model. Our analysis reveals a significant positive spatial autocorrelation of agricultural carbon productivity, indicating that mechanization has both a positive direct effect and a negative indirect (spatial spillover) effect, resulting in a negative cascading impact across regions. Robustness tests confirm these findings, and further analysis shows that these effects are more pronounced in the Northeast, with rural energy consumption playing a crucial mediating role. Notably, mechanization in provinces with strong agricultural economies can have positive spillover effects on neighboring regions. The study concludes that China’s agricultural carbon emission reduction should be approached through a collaborative, spatially linked inter-provincial strategy that promotes low-carbon mechanization and optimizes energy use, fostering a carbon-neutral community and ensuring sustainable agricultural development.

Paper ID: 391

Proposing a framework for assessing sustainability reports by Victorian universities in Australia

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Abstract:
Assessing sustainability reports by universities assists in uncovering sustainability performances of these universities and identifying their sustainability impacts since universities signal sustainability information in their sustainability reports for communicating with their stakeholders. However, assessing sustainability reports by universities often lacks emphasis on geographical differences in indicator selection and weight determination, which undermines comparison among universities in the same region for their need to improve legitimacy. This study aims to introduce a method for proposing a framework that assesses sustainability reports by Victorian universities in Australia to inform these universities about signals their sustainability reports may consider covering and emphasizing based on their actual performances and geographical characteristics for gaining legitimacy. Machine learning for Natural Language Processing quantifies and prioritizes information disclosed by the sustainability reports to construct the framework for assessing sustainability reports. The method further evaluates the extent to which local universities value each element in the framework in their sustainability reports. The result indicates that sustainability reports by Victorian universities address a broad range of sustainability concerns while emphasizing sustainability issues relating to education. By proposing this multi-organizational level framework, the study assists universities in enhancing the consistency and transparency of their sustainability reports by avoiding "sustainability washing" and reducing information asymmetry with their stakeholders. Additionally, the framework for assessing sustainability reports constructed by the study offers measurable benchmarks for universities to monitor their sustainability progress, lead actions, and refine their sustainability strategies.

Paper ID: 392

Improving food systems sustainability through the development of effective temperature-control strategies

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Abstract:
Environmental temperature plays a critical role in the efficiency and sustainability of food systems, influencing every stage of the supply chain, from production to transportation and distribution. Temperature fluctuations can negatively impact food quality, safety, and shelf life, leading to significant environmental costs, such as increased greenhouse gas emissions. Reliable temperature control is essential for maintaining optimal conditions and minimizing waste. This paper explores the significance of temperature control technologies in food systems and their role in promoting environmental sustainability. It examines eight advanced technologies, including ultra-high pressure technology for enhanced preservation, voltage electrostatic field technology for energy-efficient cooling, and cold plasma technology for non-thermal food processing. These technologies not only promise to enhance sustainability but also significantly improve food quality and safety. Additionally, the research provides a comprehensive review of the impact of temperature on food systems and presents a countermeasures framework. By emphasizing the importance of precise temperature management, this research aims to offer a framework for optimizing food system operations, enhancing environmental sustainability, and improving overall efficiency. The paper also discusses the challenges of implementing these strategies and offers insights into future developments. The findings underscore the critical need for adopting advanced temperature control methods to meet the growing demands for sustainable and resilient global food systems.

Paper ID: 393

Voluntary Behaviour Change with regard to resolving single-use plastics (SUP) problems in Vietnam

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Abstract:
Over the past six decades, the world has produced millions of tons of plastic waste, causing significant environmental impact. Vietnam ranks among the top countries regarding plastic waste discharged into the sea and landfills. Although the government has addressed these issues through legislation and national programs, their effectiveness remains questioned. Following the PRISMA process, this study employed a rapid review method to examine current peer-reviewed articles on Voluntary Behavioural Change Initiatives/Interventions aimed at addressing single-use plastic packaging problems in Vietnam and compared them to similar solutions in other countries. Intervention evaluation techniques from Bragge et al. (2023) were applied to assess key successes, barriers, and facilitators. To further strengthen the rapid review process, semi-structured interviews were conducted with practitioners currently active in resolving plastic waste in Vietnam, with subsequent analysis using thematic analysis. The results revealed that most voluntary initiatives/interventions in Vietnam were recycling initiatives conducted in informal contexts, with no studies yet assessing their effectiveness. The study identified four reusable packaging initiatives and four recycling initiatives, highlighting their effectiveness in countries like the Netherlands, Australia, the UK, and Germany. These initiatives, including deposit systems, return programs, refill programs, and strategies like door-to-door collection, voluntary drop-off points, and deposit schemes, have successfully changed consumer habits and increased recycling behaviours through carefully considering stakeholder engagement, convenience, incentives, and use of technology. Semi-structured interviews indicated challenges such as a lack of infrastructure, insufficient government support, and high costs associated with implementing reusable and recycling interventions. Lessons from successful initiatives in other countries offer valuable insights to improve existing interventions in Vietnam. Implementation considerations emphasise the importance of addressing convenience, changes in physical conditions, stakeholder engagement, and technology to ensure successful behavioural change interventions in reducing plastic waste. Future studies should evaluate the effectiveness of such initiatives in Vietnam.

Paper ID: 395

Drivers of plastic waste reduction in island communities in Central Vietnam: An application of the extended theory of planned behavior

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Abstract:
Marine plastic pollution is an urgent threat to the environment globally and locally, particularly in coastal and island communities. Anti-plastic interventions have garnered awareness and behavioral changes among local people. Tourism, a major industry in many of these communities, presents a complex factor. It boosts the local economy but also plastic consumption. However, tourism also aids pollution mitigation efforts to maintain its reputation. This study aims to investigate island residents' attitudes and behavior in marine plastic pollution mitigation, considering the influence of interventions and tourism. Data were collected from 300 residents on two adjacent islands in Central Vietnam through questionnaire surveys covering the following characteristics: with tourism and interventions, and without interventions and with or without tourism. Questionnaire items were developed based on the Theory of Planned Behavior (TPB) (i.e., attitude, subjective norm, perceived behavioral control, behavioral intention, behavior) and two extended factors, i.e., tourists' moral behavior (e.g., beach clean-up) and trust in authority. The path analysis result shows that all the TPB and extended factors were positively associated with intention and behavior. Perceived behavioral control and trust in authority were more strongly associated than other factors. Intervention was found to be a positive predictor, while tourism was found to be negative toward some factors. The intervention's success in improving residents' attitudes and behavior is likely due to educational activities and community engagement. Interestingly, tourism exerts controversial implications: it could generally discourage anti-plastic practices among local people possibly due to the economic priority, while tourists' moral behavior could facilitate such practices by inspiring locals to do the same. The findings of this study provide insights for policymakers and stakeholders in developing strategies to mitigate marine plastic pollution and promote responsible practices in plastic consumption and management in island communities.

Paper ID: 399

Analysis of greenhouse gas reduction effects through the apparel products' second-hand trading

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Abstract:
The clothing industry is a significant contributor to global greenhouse gas emissions, responsible for approximately 10% of the total. Furthermore, the industry consumes around 1.5 trillion liters of water annually during the manufacturing process. The majority of greenhouse gas emissions, about 71%, occur during the production stage due to the substantial energy required for producing raw materials, dyeing, and processing. The use and disposal stages contribute roughly 23% of emissions, while transportation and distribution account for about 6%. In light of increasing awareness of carbon neutrality and the circular economy, second-hand clothing transactions have emerged as a rational consumer choice. Previous studies suggest that purchasing two second-hand clothing items can replace one new purchase, thus avoiding the production, processing, and disposal stages associated with new clothing. This results in additional greenhouse gas reduction benefits. To effectively reduce greenhouse gas emissions in the clothing industry through increased clothing reuse, it is essential to quantify the environmental benefits of second-hand transactions. This study analyzes the greenhouse gas reduction effect of second-hand transactions for various clothing products. The findings indicate that as the number of second-hand transactions increases, the lifespan of clothing is extended, resulting in a reduction in annual greenhouse gas emissions. Although this study uniformly applied the life extension effect of second-hand transactions based on previous research, it provides valuable insights by visualizing and quantifying the greenhouse gas reduction potential of second-hand clothing transactions. These findings can serve as a useful reference for policymakers and industry stakeholders.

Paper ID: 401

Carbon Neutrality vs. Food Security: trade-offs between agriculture and energy production

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Abstract:
Developing a low carbon economy is a top priority for the Australian government, driven by its Nationally Determined Commitments (NDC) to reduce carbon emissions by 43 percent below 2005 levels by 2030 and achieve net zero emissions by 2050. In this context, utility scale solar photovoltaics (PV) and wind energy will play a pivotal role in transitioning to a low-carbon economy. This transition necessitates an unprecedented expansion of renewable energy (RE) resources, primarily solar and wind. The land-intensive nature of RE resources will likely intensify competition for land use between agriculture and energy production. This study focuses on examining the economic trade-offs between renewable energy development and agricultural land use. Data on direct normal irradiance (NDI), slope, aspect, proximity to distributional network, average annual temperature, wind speed, and existing land use classification will be used to develop a GIS-based spatial suitability model that identifies land areas with high solar and wind potential across New South Wales (NSW), Australia, which are currently under agricultural production. This model will be used to measure site-specific trade-offs between renewable energy production and traditional agricultural production activities, expressed as the value of agricultural production lost per unit of renewable electricity produced per hectare of land. This analysis will involve: assessing region-specific theoretical and technical energy production potential from renewables, and evaluating the environmental and economic implications of land use change. The findings of this study will contribute to the growing body of knowledge on the complex interactions between land use, energy production, and sustainable development, ultimately supporting global efforts to mitigate climate change while maintaining agricultural productivity and food security.

Paper ID: 403

Substitution of automobile shredder residue (ASR) for coal in smelting furnace fuel: Application of jig separation for the removal of glass and metallic components from ASR

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Abstract:

Automobile shredder residue (ASR)—the leftover material after a vehicle has been dismantled and valuable metals have been extracted through shredding and sorting processes—contains resins, which can be used as a fuel in the smelting process instead of coal when non-burnable materials (e.g., glass and metals) and chlorine-containing polymers are removed. As non-burnable glass and metals are heavier than resins, this study investigated the applicability of the jig separation for ASR under 4 mm to produce a combustible concentrate with low ash content. The float and sink analysis for +2.0–4.0mm of ASR samples to identify ash contents in each specific gravity fraction confirmed that the sample of which specific gravity (SG) is <1.4 contained around 10% ash, while it increased to about 90% for the sample with SG >1.5. However, jig separation result showed that the overall separation efficiency was only approximately 35% because of fiber-like materials causing the entanglement of metals (e.g., copper wires) with it. After removing the fiber-like materials before jig separation, the separation results were significantly improved to about 65%, but the efficiency was still lower than the expected value based on the result of the float and sink analysis. To investigate the effects of particle size on jig separation results, a theoretical calculation method was established based on settling velocities calculated using particle size and specific gravity of each particle. Through this theoretical calculation, the jig separation results can be expected and compared with the experimental results, indicating that effects of particle size on jig separation are not significant, while other factors like the shape of the particles may negatively impact the process.

Paper ID: 404

An evaluation framework for carbon metabolism at community scale: a case in China

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Abstract:
Cities are recognized as a major source to global warming. As the cell of city, urban communities play an increasingly important role in carbon emissions mitigation with the accelerating urbanization. Carbon metabolism is recognized feasible to model the carbon cycle among the components in a community ecosystem from a system-oriented perspective, which could reveal interactions among components and assess the carbon emissions for low-carbon development. However, the carbon metabolism characteristics at community scale remain largely unexplored. Herein, we establish a system-based framework for modeling the dynamics of carbon metabolism through time at community scale. Using a mixed-function community in China as a case study, we track the trajectory of carbon flows and examine their inner relationships. This study provides an insight by investigating the temporal dynamics and characteristics of carbon metabolism at community scale, and reveals the metabolic mechanism by opening the community ‘black box’. It suggests that the carbon mitigation in community level need to combine both internal and external approaches. In this case, effective and targeted low-carbon management pathways could be potentially explored at sector and community level for distinguished policies implementation and shed lights with development strategies on other similar communities.

Paper ID: 406

Low-carbon and zero-energy building exterior climate-based design strategy

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Abstract:

Abstract. Controlling carbon emissions and energy consumption is an urgent issue that has become the research focus in many fields. As for the construction industry, which accounts for 34% of carbon emissions, wooden buildings are a potential solution for the environment-friendly transformation due to their carbon storage capacity and low energy consumption. The existing wooden building environmental assessment systems evaluate materials from two separate dimensions: low-carbon and zero-energy. Different assessment systems not only affect the comprehensive assessment of the environment-friendly performance of wooden buildings but also hinder cross-regional communication of related achievements. How to build a life-cycle assessment system and realize the climate-based selection system for wooden building insulation exterior materials is a problem that needs to be solved. This paper reviews the existing carbon emissions and energy consumption assessment criteria, applying the Building Environmental Assessment modeling approach to establish a comprehensive low-carbon and zero-energy assessment system based on the Life Cycle Assessment modeling approach. Then, this paper creates a System Dynamics Model by applying the Multiple Criteria Matrix approach to assist the entire exterior design process. Compared with the existing studies, the life-cycle assessment system of wooden building exteriors proposed in this paper integrates the existing carbon emissions and energy consumption assessment criteria and suggests a comprehensive method to control the life cycle carbon emissions of wooden building exteriors. This paper also constructs a comprehensive conversion system, realizes the comparison of design and research among different countries and regions, and is of great value in promoting international exchanges and cooperation in related fields. A climate-adaptation design strategy is proposed for seven climate regions in Japan, which will be valuable in realizing low-carbon, zero-energy buildings.

Paper ID: 407

An investigation into factors influencing the adoption of technical solutions to resolve resource dilemmas.

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Abstract:
This study investigates factors that influence the choice to adopt technical solutions to resolve resource dilemmas. In particular, this study examines the effect that personal norms (Schwartz, 1977) and environmental worldview (Dunlap & van Liere, 1978) have on consumer participation in a water conservation initiative – the Australian Showerhead Exchange Program. In addition, the spillover effect of pre-existing pro-environmental behavior as well as socio-demographic characteristics were included within the model, and their impact on program participation was examined. Hierarchical binomial logistic regression was employed to analyze survey responses from a cross-section of 1693 households across Australia. Analysis revealed that environmental worldview, pre-existing pro-environmental behavior, family lifecycle and household income significantly influence program participation. The study also revealed the construct of environmental worldview as three-dimensional in the context of this study, rather than a uni-dimensional as originally proposed by its creators (Dunlap & van Liere, 1978). Further, this study has revealed that the anti-exmptionalism theme expressed within the New Ecological Paradigm (a measure of environmental worldview) is representative of environmental concern when technology adoption rather than behavioral options are assigned as pro-environmental choices. The findings in this study are represented in a parsimonious model that advances policy makers' capacity to formulate pro-environmental campaign messages that are precisely targeted and applicable across pro-environmental domains.

Paper ID: 409

Acceptance of UAVs in agriculture: An empirical study of China's Jiangxi Province

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Abstract:
The immense technological progression of Unmanned Aerial Vehicles (UAVs) technology has supported its use in Digital Agriculture for crop health monitoring and protection. Nevertheless, the adoption rate of plant protection UAVs on a large scale is very low around the globe, including China. Therefore, in this study, we have used the Structural Equation Model (based on Adapted TAM) to investigate the factors affecting the promotion of plant protection UAVs in China. Data from 260 rice-growing farmers (in seven cities of Jiangxi province) was collected via online and offline surveys to conduct this empirical analysis. The results show that perceived usefulness, ease of use, and network externalities positively promote farmers' willingness to adopt plant-protection drones. On the contrary, it is observed that perceived risk negatively affects the intention to adopt UAVs for crop protection. Finally, it is concluded that the results are of interest to improve the promotion policies in terms of considering the psychological perspectives of farmers towards adopting plant protection UAVs.

Paper ID: 410

Unravel alternatives to conventional resources for sustainable infrastructural development- A review and critical assessment

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Abstract:
Depleting natural resources from the construction sector has triggered project managers to work cautiously on the optimum use of resources like aggregate, bitumen, etc. India does have good deposits of parent sources for various resources like aggregate. Still, at every source, the physical properties do not meet the construction standards proving the inadequacy for use. Increasing infrastructural development, wastage during actual working, and shortage of construction physical resources are forcing researchers to work on finding alternatives. A three-step method is applied for the study wherein the literature is surveyed in depth on various depleting and falling short resources used in highway infrastructural projects, followed by prioritization and defining the regional requirements, and review and evaluation of depleting resources. From the rigorous literature survey, it is observed that a wide variety of waste materials are used as an alternative to conventional materials. An investigatory study has been made to scale the suitability for utilizing waste materials like scrap rubber, bagasse ash, sugarcane husk, E-waste, Reclaimed Asphalt Pavement (RAP), waste plastic, demolition construction waste, incinerated ash, etc. as a partial replacement in construction materials to make construction more sustainable and cost-effective. The use of waste materials as a partial replacement proves to be a sustainable solution for the problem of exhausting natural resources. Eco-friendly alternatives and benefits of recycling are intended for sustainable decision-making for engineers as it should be comprehensive enough to avoid the burden of shortfall of materials and to mitigate the problem of ever-increasing demand.

Paper ID: 412

Characteristics of gluten-free dry noodles from arrowroot tuber flour with added hydrocolloid Carboxymethyl Cellulose (CMC)

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Abstract:
Arrowroot tubers represent a promising alternative food source with the potential to contribute to the sustainability of natural resources. One of the applications of arrowroot tuber flour is the production of gluten-free noodle products. The present study undertook a comprehensive evaluation of gluten-free dry noodles produced from arrowroot tuber flour with the addition of a hydrocolloid Carboxymethyl Cellulose (CMC). This study aimed to evaluate the impact of CMC incorporation on the quality of gluten-free noodles. The quality of the noodles was assessed based on their physical and chemical characteristics. The study was conducted by adding CMC to gluten-free noodles at four levels: 0% (control), 0.5%, 1%, and 1.5%. The results show that CMC influences the physical and chemical quality of noodles. A simultaneous increase in the resulting noodles' ash, fat, and moisture content accompanied an increase in CMC concentration. The addition of CMC resulted in a significant increase in the redness and yellowness of the noodles without a corresponding decrease in the whiteness index. Furthermore, the addition of CMC significantly affected the elongation, cooking time, and water absorption of the noodles. Therefore, the addition of CMC is a viable approach and can used to develop gluten-free noodles.

Paper ID: 414

Challenges and strategies in achieving sustainability in the automotive industry: A case study using the EFQM Model

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Abstract:
The automotive industry currently faces slowdown due to a decline in car sales and a volatile market. Such environment presents a prime opportunity for implementing various improvement measures ranging from robotization to the integration of sustainability initiatives. Implementing change in corporate organizations involves navigating complex challenges that encompass reconciling the strategic goals of the headquarters with market conditions and specific factory needs. This research examines the past, present, and planned activities of a factory within a global corporation, focusing on sustainability efforts. Between 2022 and 2023, significant achievements were recorded with a 9% reduction in electricity consumption, alongside plans for an additional 12% reduction next year. However, the factory's total energy consumption is 13 GWh yearly, expected to rise with new projects. Unfortunately, in-house electricity generation via photovoltaics was found impractical due to roof constraints, offering on the available surface a negligible 0.5% consumption reduction with a payback period of 58 months. Despite a 41% reduction in gas usage for heating, increased production offset these savings, underscoring the challenges in meeting Net Zero targets. The complexity of managing large-scale organizational can both facilitate and hinder the implementation of innovations. Small, isolated projects are unlikely to yield substantial savings in energy, gas, and non-renewable resource consumption. The purchase of green certificates has proven ineffective in fostering true sustainability within the organization studied. Effective sustainable management requires a holistic approach supported by modern technologies such as real-time data collection, big data analytics, and AI. These tools enable agile, informed decision-making across the organization. The EFQM Model, particularly its 2025 update focused on sustainability, could serve as a crucial framework for enhancing organizational sustainability. An analysis of organizational readiness based on this model identified potential areas for improvement, highlighting the need for a comprehensive strategy to address the multifaceted nature of sustainability challenges.

Paper ID: 415

Mitigation potential of CO2 emissions by catalytic upcycling waste plastics into CNTs-based composites worldwide

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Abstract:

The increasing amount of discarded waste plastics causes significant environmental problems. Conventional mechanical and energy recovery methodology for waste plastics treatment is inadequate due to the complex components within plastic waste, necessitating the development of a sustainable and green upgrading pathway to achieve more value-added products. An innovative approach was proposed for production of high-quality carbon nanotubes (CNTs) using discarded waste polypropylene as a low-cost carbon source with a series of Fe/Co/Ni-loaded oxide support catalysts. Through the life cycle assessment (LCA) method, we quantified the environmental impacts of the proposed approach with different Fe loading of samples (10wt%,30wt%, and 50wt%) for six typical types of waste plastic and founded that the most environmental one could save more than 90% carbon emissions compared to incineration. Based on the environmental impact results, mitigation potential of CO2 emissions was quantified in OECD and non-OECD countries. An annual saving of about 30 million tons of CO2 emissions was realized. Uneven potential was observed between OECD and non-OECD countries. To achieve global environmental sustainability in the long run, countries should adopt the suitable treatment approach according to the plastic waste composition.

Paper ID: 417

Tracking iron and carbon flows in multi-regional steel industry chain: an energy-material-economy nexus analysis

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Abstract:

Realizing the low-carbon development of steel industry chain is significant for global low-carbon transition and sustainable development, which requires coordinated efforts from multiple regions and sectors along the entire industry chain, both upstream and downstream. Accurately tracking the iron and carbon flows within multi-regional steel industry chain (MRSIC) is an essential first step in these efforts. To address this issue, this study proposed a unified analytical method by integrating energy and material flow analysis, extended multi-regional input-output model, and energy consumption and carbon emission accounting. By applying the method to a case study involving 10 regions of China in 2017, this study tracked the iron and carbon flows from multi-regional energy and mineral supply to final demand. The results revealed that the main line of iron and carbon flows in China's MRSIC was from the west to north, then to the east and south, finally to the central and southwest. The northern coastal region imported large volumes of iron ore, and consumed coal from the middle reaches of the Yellow River for steel production, resulting in substantial carbon emissions. Subsequently the steel was transported to the eastern and southern coastal regions to produce final products for export and satisfying the final demand of the central and southwestern regions. The findings indicated that gross capital formation, mainly led by the central region and construction, drove 78.4% of China's steel production and related emissions, while exports, primarily led by the eastern and southern coastal regions and manufacturing, contributed 10.8%. This method can provide support for understanding the complex interrelationships among energy use, material demand and economic growth within the MRSIC.

Paper ID: 418

The role of industry structure and firm performance in determining entry timing for energy service companies

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Abstract:
Abstract: As environmental challenges intensify globally, energy conservation and emission reduction have emerged as critical priorities. In China, the energy service industry has experienced rapid expansion, drawing numerous companies into the sector. However, many of these companies, having entered the market without adequate preparation, have faced disappointing outcomes. This paper investigates the key factors influencing companies' decisions to enter the energy service market, utilizing industrial organization theory as the analytical framework. Six indicators across two dimensions—market structure and performance—are examined: industrial concentration, industry growth, industrial policy, company size, solvency, and profitability. The results of multiple linear regression analysis reveal that rapid industry growth and strong solvency significantly encourage market entry, while larger company sizes and an unfavorable policy environment deter participation. Based on these findings, the study suggests that the government should increase financial subsidies, and energy service companies should cautiously manage expansion and focus on financial risk control.

Paper ID: 421

Using inert waste as support material for the development of biological barriers

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Abstract:
The present study aimed to evaluate the use of waste as support material for developing bio-barriers within the landfill design. The experimental setup consists of vertically positioned PVC columns (50 mm in diameter, 600 mm in length), through which the flow will ascend from bottom to top. The columns were filled with different mixtures of inert wastes (construction and demolition fine aggregates – CDW – and/or tire waste – TW) and were compacted adapting the standard Proctor test parameters (12% optimum moisture content). Some columns were inoculated with anaerobic biomass obtained from a digester treating sewage sludge in Madrid, Spain (7000 mgTS/L, 120 mgVS/L). The columns were fed with raw leachate collected from an active municipal landfill in Madrid, Spain (dissolved organic carbon (DOC)≈150 mg/L, pH≈7.8, electrical conductivity (EC)≈10 mS/cm, oxidation-reduction potential (ORP)≈ –150 mV, dissolved oxygen (DO)≈0.0 mg/L). Head loss and flow measurements enabled to calculate the permeability of the materials over time (Darcy's law). Inlet and outlet samples were collected daily (pH, EC, ORP, DO, temperature) and biweekly (cations, anions, trace elements, DOC). After 6 and 12 months, the columns will be opened to perform biofilm analysis, surface imaging, and semi-quantitative compound analysis. The preliminary results show a permeability reduction of 1-2 orders of magnitude, depending on the column composition, achieving hydraulic conductivities of until 10-6 m/s in 120 days. The lowest values were associated with the columns filled with a mixture of CDW and TW 50% v/v, possibly showing it works as a better support for biofilm development. It is expected that the columns reach hydraulic conductivities of about 10-9 m/s before 12 months of operation, which is compatible with the minimum legal values for the compacted clay liners used in landfills. This bio-barrier would protect the clay liner, increase its lifetime, and potentially reduce its thickness.

Paper ID: 422

Stability and maturity of paper mill sludge aiming agricultural application

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Abstract:

Using sludge as soil enhancers can promote the circular use of nutrients; however, their application must be carefully evaluated to avoid the introduction of pollutants and/or the impairment of soils and crops. The objective of this research was to evaluate the suitability of using paper mill sludge as soils enhancers, by means of stability and maturity studies, and phytotoxicity bioassay. For evaluating stability, the Specific Oxygen Uptake Rate (SOUR) was assessed, while maturity was evaluated by means of germination indexes (GI) and normalized residual radical elongation. The treatments were: fresh dried sludge, sludge with thermal treatment (100°C for 90 min) and control. Germination was evaluated by placing 20 seeds in 10 g of each treatment. For the control, absorbent paper was used. The analysed seeds were radish, lettuce, barley, alfalfa, fescue, and wheat. A germination chamber was used with a photoperiod for 7 days, at a temperature of 25°C. The stability results showed oxygen consumption ranging from 10.7 to 44.5 mgO2/g VS.d, which was considered high according to different international standards. Thus, the sludge could not be considered stable, undergoing degradation, and consuming the soil's oxygen if disposed of without a previous treatment. The highest germination rate was obtained for fescue seeds, with values of 70% and 68% for fresh and thermally treated sludge, respectively. Nevertheless, the other studied species showed high phytotoxicity. The stability and maturity assays showed that the paper mill sludge is not appropriate for agricultural applications, presenting phytotoxicity in most cases and causing impacts on soils. Thus, it must be previously treated (e.g., composting) before being used as a soil enhancer. The performed analyses showed to be fundamental when evaluating the suitability of reusing wastes for agricultural purposes.

Paper ID: 423

From coal to clean: A novel energy system for transforming critical material production

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Abstract:
The surging demand for critical minerals, essential for renewable energy transition, has intensified scrutiny on the environmental footprint of their production. The metallurgical industry, especially those involved in critical material production like nickel processing, significantly contributes to greenhouse gas emissions due to its dependence on fossil fuels. Although electric vehicles (EVs) and other clean technologies present a promising path to decarbonization, the production of materials for these technologies remains carbon-intensive. This discrepancy underscores the need to address the substantial carbon footprint associated with critical material production. This study investigates alternative energy resources and technologies to decarbonize these fossil-intensive processes. We analyzed three primary options for replacing captive coal power: coal-biomass co-firing, photovoltaic (PV) systems combined with battery energy storage, and concentrated solar power (CSP) for combined heat and power (CHP). Each of these alternatives offers distinct advantages but also faces significant limitations regarding energy stability, capacity sufficiency, and environmental impact. Co-firing coal with carbon-neutral biomass can reduce carbon emissions and diversify the fuel supply, but coal use still contributes to climate harm. PV and battery storage offer flexibility and cleaner energy but may struggle to provide consistent 24/7 power and heat. CSP with CHP delivers high efficiency but demands significant investment and infrastructure. To overcome these challenges, we propose a novel energy system that integrates biomass, biogas, PV, and advanced energy storage technologies. This comprehensive approach is designed to achieve net-zero carbon emissions while maintaining a reliable and sustainable electricity and heat supply for critical material production. By aligning with broader decarbonization goals, this integrated system aims to deliver a truly zero-carbon footprint, supporting the energy transition's sustainability and effectiveness.

Paper ID: 424

Revealing the synergistic effects of CO2 and air pollutants in the industrial sector of the Pearl River Delta urban agglomeration

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Abstract:
The Pearl River Delta (PRD) is a representative urban agglomeration with high economic vitality and industrialization in China. The rapid industrialization is accompanied by a surge in energy consumption in the industrial sector, producing large amounts of CO2 and air pollutants. Therefore, the synergistic emission reduction of CO2 emissions and air pollutants in the industrial sector is the key to achieving the goals of CO2 emission reduction and air quality standard. In this study, a comprehensive analytical framework is constructed to reveal the synergistic effects between CO2 and multiple air pollutants (including SO2, NOx, CO, PM10, PM2.5, and VOCs) in the PRD and its surrounding cities from 2012 to 2021 by combining the spatial and temporal evolution patterns, correlation analyses and coupling coordination. Additionally, we further quantified the synergistic effects between CO2 and atmospheric pollutants based on LMDI and econometric models. We found that air pollutants and CO2 have similar emission characteristics, and air pollutant emissions are higher in regions with high CO2 emissions; Specifically, before 2014, the emissions of CO2 and air pollutants in Guangdong originated primarily from the PRD, and after 2014, they originated primarily from the surrounding cities. CO2 emissions and the six air pollutant emissions show significant positive correlations of different degrees. Compared with other air pollutants, NOx has a higher synergistic effect with CO2. Based on this, we further reveal the effect of CO2 emission on NOx emission, and we found that the contribution of synergistic effect to NOx emission reduction gradually increases with time, and CO2 emission reduction will significantly affect NOx emission reduction. Every 1 Mt increase in CO2 emission reduction, the NOx emission reduction will increase by 1873 tons. Considering the important role of NOx in compound air pollution, synergistic control between CO2 and air pollutants is expected to be realized.

Paper ID: 427

Shenzhen's investigation and optimization strategies for construction and demolition waste recycling mechanisms

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Abstract:
As a pilot city for China's "Zero-Waste City" initiative, Shenzhen has implemented policies to regulate the recycling and utilization of construction and demolition waste at the building level. However, the increasing volume of this waste has led to significant challenges in its disposal. This paper conducts an on-site investigation of the entire process of construction and demolition waste disposal in Shenzhen, analyzing the various types of waste generated from the removal of building components and their actual disposal methods. The study identifies existing problems in Shenzhen's waste recycling mechanisms and proposes optimization strategies to alleviate the disposal pressure of construction and demolition waste in the city. These strategies also provide valuable insights for other cities in China.

Paper ID: 428

Investigating evolution and viability of circular business models for plastics in Hong Kong

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Abstract:
Plastic streams are a prevalent resource and waste problem: Production is emission intensive, around 50% of global plastics are single-use or short-lived packaging and global recycling achieves a mere 10% of production. This calls for circular approaches which go beyond recycling, e.g. material substitution, reduction and reuse, and replace functionality in a consumer-acceptable manner. In the Hong Kong SAR, where plastics constitute around 21% of MSW, COVID-19 and a partial ban on single-use and packaging plastics (SUPPs) has opened a window of opportunity for circular business models (CBMs) on plastics. This submission centres on local CBMs for SUPPs and investigates: (1) What are the evolutionary patterns of heuristic learning among SUPP-CBMs? (2) Are SUPP-CBMs viable in the sense of expanding and profiting from operations? To tackle these questions a mixed methods approach is used. First, the investigation combines a 'success-factor-and-barriers' framework with an analysis tool derived from evolutionary institutional economics. This explores if and how CBMs managed individual challenges longitudinally, i.e., from pre- to post-COVID-19 and over the implementation of Hong Kong's category-specific SUPPs ban. Second, residents' preferences and consumption patterns regarding CBMs on SUPPs are statistically evaluated. These analytical operations use new empirical data stemming from (1) in-depth interviews with CBMs (n=13) and (2) two, so far unpublished surveys on circular preferences and consumption patterns of Hong Kong residents (n=1,001 and n=790). The findings show that consumer sentiment and behaviour is overall supportive of higher-ranking circular business solutions for plastics, but less so for food and beverage packaging. Relevant CBMs have however benefitted from growing awareness among consumers and the local plastic ban over time. A key success factor in strategies was to integrate feedback from consumers into individual circular business solutions, which nevertheless remain constrained by high initial costs and a lack of fiscal policy support

Paper ID: 430

Commuting GHG emissions assessment for higher education institutions

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Abstract:
Universities play a crucial role in the climate change agenda, and several have established goals to reduce emissions. Commuting of students and employees is known as one of the primary sources of greenhouse gas (GHG) emissions for universities. Although they are indirect emissions, their mass and the ability of institutions to influence them justify programs and projects dealing with them. One of the challenges in achieving carbon neutrality is the accurate quantification of GHG emissions. GHG commuting inventories are rare due to the need for more structure and methods to collect data. This study addresses this gap by developing a method for quantifying the indirect emissions associated with students, faculty, and staff commuting at the University of São Paulo (USP). The technique relies on digital surveys targeting USP's community members. The research encompassed diverse profiles, including students, faculty, technical and administrative staff, and third parties across various USP campuses, resulting in 400 responses. The data collected allowed for a detailed analysis of the participants' commuting practices, revealing that commuting emissions are the main contributors to scope three emissions, underscoring the importance of these sources within the university context. This work validates the proposed methodology for quantifying commuting emissions and identifies challenges and opportunities for effectively including indirect emissions in GHG inventories. The potential impact of this research on other institutions is significant, offering hope and inspiration for a collective effort toward carbon neutrality. The results also bring initial thoughts on what projects can be implemented to minimize commuting emissions, aiming at specific profiles of faculty, employees, and students. By offering a practical approach to managing indirect emissions, this research empowers institutions and individuals to make meaningful contributions to global efforts in the transition to carbon neutrality.

Paper ID: 433

Critical review of the whole life carbon impact of large-scale residential retrofit at a national scale

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Abstract:
Worldwide, retrofit of our residential buildings is a common go-to strategy as we aim to reduce our carbon emissions. Ireland has committed to ambitious targets for reducing greenhouse gas (GHG) emissions by 2030, focusing significantly on emissions from residential sectors. This study investigates the impact of Embodied Carbon (EC) costs on the Whole Life Carbon (WLC) associated with Ireland's large-scale retrofitting initiative, examining two distinct scenarios. The first scenario, based on previous research, estimated that retrofitting 500,000 homes with measures like adding insulation, photovoltaic systems, and heat pumps will result in an additional 10 MtCO2e of EC over a decade. This increase represents an annual addition of 1 MtCO2e, which equates to the addition of over half of the current annual EC of 1.8 MtCO2e for residential buildings. Despite this, the study projects significant OC savings, estimating a reduction of 2 MtCO2e per year if the retrofit succeeds in achieving carbon reduction as planned. By 2030, the overall OC reductions are expected to reach 20 MtCO2e, and by 2050, this could total 60 MtCO2e, representing a 57% reduction in OC. The payback period for offsetting the additional EC with OC savings is calculated to be 5 years. Second scenario, the study evaluates the EC costs per square meter across different housing types. The first approach estimates the individual average total floor area for each type. This corresponding EC values detached houses 174 kg CO2e/m² to apartments 181 kg CO2e/m². The second approach considers an average floor area for all types of dwellings as 113 m², resulting in an EC value of 177 kg CO2e /m². In conclusion, while retrofitting increases EC, the significant reduction in OC leads to a net decrease in total emissions over time and is crucial for achieving long-term sustainability in the building sector.

Paper ID: 434

Implementing circular economy models in industrial plants: A case study of integrated technological systems

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Abstract:
The transition to a circular economy is a critical goal for industrial plants in the coming years. This approach necessitates a comprehensive analysis of the entire product life cycle, from raw material sourcing through production and consumption to the secondary utilization of waste. This study assesses the feasibility of creating an autonomous energy island composed of several interconnected industrial facilities, optimizing their operations to meet current production needs. The analyzed system includes a biogas plant, an agricultural distillery, a domestic and industrial sewage treatment plant, a waste incineration plant, and a carbon dioxide recovery installation. The distillery, with a capacity of 1,600 L/h of distillate, produces approximately 300 m³/day of stillage, which serves as a primary substrate for methane fermentation in the biogas plant. The biogas plant, with a capacity of 2 x 2 MW, requires 2 x 200 m³ of substrate per day, 75% of which is supplied by the distillery. Heat recovery is optimized through a steam boiler connected to the biogas plant, supplemented by heat from the waste incineration plant. The sewage treatment plant processes 200 m³/day of wastewater, contributing to the circular flow of materials within the system. The integration of these facilities creates a self-sustaining energy ecosystem, reducing dependency on external resources and aligning with the principles of the European Green Deal. The model demonstrates that the synergy between these plants can achieve substantial energy efficiency and waste reduction, supporting sustainable development and the circular economy. This study offers a practical framework for industrial parks aiming to transition from linear to circular economy models, with significant environmental and economic benefits.

Paper ID: 435

Blockchain for inclusive forest-carbon markets: struggles and opportunities

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Abstract:
Forest-carbon projects present valuable opportunities for forest owners by supporting sustainable management practices and contributing to climate mitigation. However, these projects are often criticized for excluding underserved landowners due to their complexity and high transaction costs. Additionally, concerns over perverse incentives and a lack of transparency can reduce the value of carbon credits. Blockchain technology, when integrated with remote sensing, AI, and IoT data, offers a potential solution by enhancing transparency, streamlining project implementation, enabling decentralized governance, and fostering smallholder inclusion in forest-carbon markets. Despite its promise, blockchain remains nascent, fragmented, and frequently overshadowed by technological hype, complicating objective assessments of its effectiveness. This study examines the current state of the forest-carbon blockchain industry, identifying ten leading organizations developing blockchain solutions for forest-carbon projects in the Global South. Through in-depth structured interviews, we uncover common political, socioeconomic, and technical challenges these organizations face. Our findings suggest that while blockchain technology has the potential to enhance transparency and inclusivity, significant obstacles persist, including regulatory uncertainty, limited technical capacity among stakeholders, and difficulties in integrating blockchain with existing carbon market frameworks. Additionally, the tendency for blockchain initiatives to prioritize technocentric solutions over the nuanced needs of local communities risks exacerbating existing inequities. We argue that for blockchain to effectively contribute to forest-carbon markets, it must be implemented with careful consideration of local contexts, active stakeholder engagement, and a focus on co-benefits beyond carbon sequestration. As emerging technologies like blockchain continue to shape our interactions with the natural world, it is crucial to guide these developments toward a sustainable and equitable future for both people and the planet.

Paper ID: 440

Carbon Nutrient and Water Wasted via Food Loss and Food Waste in a tourist City

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Abstract:
The aim of the research is to thoroughly analyze food loss, waste, and the associated phosphorus and water footprint loss related to food loss and food waste in Chiang Mai Municipality, Thailand. This study specifically targets the loss and waste from major fruits and vegetables (kales, Chinese cabbage, cabbages, lettuces, chili peppers, broccoli, potatoes, baby corn, radishes, carrots, onions, mangoes, pineapples, longans, bananas, oranges, melons, papayas, tomatoes, bell peppers, and cucumbers) utilized in local markets, hotels, and restaurants. The findings reveal that food loss and waste in the area amount to 5,675 tons/year, with over 90 percent of this waste being collected for landfill disposal. This loss correlates with a phosphorus and water footprint of 1.48 t P/year and 2.36 million m3/y. The paper evaluates improvement management practices, emphasizing that careful analysis of tradeoff benefits is necessary before selecting the optimal solution.

Paper ID: 442

Assessing the Fate of End-of-Life Solar Panels: Quantification, Forecasting, and the Imperative for Circular Economy Strategies

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Abstract:
Solar photovoltaic (PV) technology has rapidly matured over the past decade, becoming a key player in the global renewable energy landscape. By 2050, electricity is expected to account for over 50% of total energy use, with solar energy supplying about 45% of global electricity needs. The International Energy Agency (IEA) projects that solar energy will make up nearly one-third of global electricity generation by 2050, increasing twentyfold from today's levels. This growth raises concerns about the availability of raw materials for PV manufacturing and the management of End-of-Life (EoL) solar panels, as the surge in usage leads to a corresponding increase in discarded panels. This research examines global and national PV roadmaps, focusing on the lifecycle of solar panels from 2000 to 2050, with the goal of forecasting and understanding end-of-life (EoL) dynamics. The study aims to develop effective EoL management strategies tailored to low-, middle-, and high-income countries. As the world's largest producer and deployer of solar panels, China is projected to install over 200,000 units by 2060. However, this rapid expansion will lead to significant challenges, with the accumulation of discarded PV modules expected to begin in 2025 and grow exponentially, reaching peaks of approximately 55-58 Kt of EoL solar panels by 2060. While Europe has established regulations for PV module recycling, many countries, including China, still lack specific legislation. This research underscores the need for robust circular economy strategies to support the sustainable growth of the solar industry and ensure effective EoL management globally. Ongoing efforts to forecast and analyze the future PV industry country-by-country and identify best practices in circular economy strategies will provide crucial insights for developing effective and technically feasible EoL solar panel management solutions.

Paper ID: 444

Application of rice husk-derived zeolites for green roadway production for enhanced resource sustainability & reduced environmental impact

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Abstract:
Rice husk (RH) and rice husk ash (RHA), which are abundantly available silica-rich agricultural wastes can be used in synthesizing zeolites and commonly used in roadway applications to promote cleaner production. The major objective of this research study was to synthesize a set of zeolites from RH and RHA, which could act as foaming warm-mix asphalt (WMA) additives for reducing the production and placement temperatures of asphalt mixtures. The scope of the effort encompassed: (i) extraction of silica from RH to obtain white rice husk silica (RHS), (ii) synthesis of six different zeolites from RHS and RHA at three crystallization temperatures (90, 100, and 110 oC) using hydrothermal method, (iii) thermogravimetric analysis (TGA) on the synthesized zeolites to select the best suitable foaming WMA additive, (iv) determination of reduction in mixing and compaction temperatures of the WMA additive, and (v) theoretical calculation of energy consumption and greenhouse gas (GHG) emissions due to reduced temperatures. The study revealed that RHA acted as the best precursor to synthesize foaming WMA additives compared to RHS. Further, RHA-derived zeolite demonstrated a maximum water content in the crystal structure ascribed to the maximum weight loss of about 10% in the range of 85-180 oC indicated by the TGA. The mixtures modified with RHA-derived zeolite depicted a reduction of about 5-10 oC in the mixing and compaction temperatures compared to the control asphalt mixtures. Finally, the theoretical environmental assessment remarked that the addition of RHA-derived zeolite reduced the fuel consumption and GHG emissions by about 5%. It is envisioned that the developed foaming WMA additive will not only foster the principles of resource sustainability but also supports the practices of cleaner production.

Paper ID: 445

Utilization of recycled plastics in asphalt-rubber roads: A green solution to solid waste management

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Abstract:
With the increasing focus on sustainable alternatives to natural resources and a vital need to manage the accumulation of solid wastes such as plastics and end-of-life tires, the integration of recycled plastics (RP) and crumb rubber (CR) into asphalt mixtures will promote environmental sustainability. The major objective of this study was to explore the suitability of utilizing the RP materials in asphalt-rubber (AR) mixtures through the semi-dry process by assessing the effect of these materials on the mixture volumetrics and moisture resistance. The scope of the effort included: (i) preparation of AR binders at varying CR dosages (10, 15, and 20% by weight of the asphalt binder) on two base asphalt binders (AC-10 and AC-30), (ii) fundamental and advanced rheological assessments on the virgin and AR binder blends, which includes Penetration, softening point, ductility, viscosity, elastic recovery, performance grade (PG), and multiple stress creep and recovery (MSCR) tests along with optimizing the AR binder, (iii) Superpave mix-design comprising 32 mixtures incorporating two RP dosages (5 and 10% by weight of the aggregates) and obtaining the mix volumetrics, (iv) moisture susceptibility test of the conventional and modified mixtures to study the effect of RP and CR on the moisture-induced damage, and (v) determination of environmental assessment indicators through lifecycle assessment. The findings revealed that the RP-modified AR blends had high elastic recovery and stiffness at high temperatures, which indicated enhanced rut- and moisture-resistance of the asphalt mixtures. Further, environmental assessment demonstrated a significant reduction in global warming potential and other environmental indicators, attributed to the conservation of natural resources through the use of RP and CR in asphalt mixtures. This not only contributes positively to resource sustainability but also paves the way towards greener and more durable pavements.

Paper ID: 447

Large language model-driven interventions to mitigate carbon footprints of high-income groups

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Abstract:
High-income individuals contribute disproportionately to global carbon emissions, making them a critical target for climate mitigation efforts. Despite their significant impact, there is a limited understanding of how to effectively influence this group's behavior to reduce their carbon footprint. Current research on behavioral interventions often overlooks the complex socio-economic and cultural factors that shape the responses of affluent populations across different countries. This study addresses this gap by exploring the efficacy of various behavioral interventions aimed at reducing the carbon footprint of high-income individuals in four diverse countries—Denmark, India, Nigeria, and the United States. We conducted a novel experiment based on the responses from 4,003 real-world participants, with 50% drawn from the top 10% income group, and compared their responses to those generated by a large language model (LLM) acting as a virtual agent. The interventions tested included information campaigns, monetary incentives, social norm cues, and moral appeals, all designed to influence sustainable behavior. To ensure comparability, the initial conditions of both the LLM and real-world participants were carefully calibrated. Our findings demonstrate that high-income individuals show significant responsiveness to targeted interventions, particularly those involving social norm cues and moral appeals, which led to measurable reductions in their carbon footprint. The LLM simulations effectively mimicked the decision-making processes of high-income individuals, offering a cost-effective and scalable tool for refining and optimizing interventions before real-world application.

Paper ID: 448

Combatting Food Loss and Waste along the food production to consumption chain: the role of monitoring systems.

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Abstract:
Food Loss and Waste (FLW) leads to societal and economic burden and also has substantial environmental impact The United Nations formulated food waste reduction targets within SDG 12.3 with the aim to halve global food waste by 2030. In Europe, food waste is estimated at approximately 88 million tons per year, which Is responsible for a significant environmental impact of the food supply. The Netherlands wants to be the first country in Europe to reach the 50% food waste reduction goal. The lack of consistent tools for measuring and monitoring food loss and waste exacerbate the food waste problem. The goal of our research is to assess existing tools and models for food waste monitoring and reporting in the food production to consumption chain, in order to understand the impact monitoring has on decision making. A consistent suite of measurement and monitoring tools for different actors in the food supply system will enable the business owners and policy makers gain a better understanding of their waste streams and take actions to prevent and minimize food waste. In this paper we focus on monitoring tools for food waste aiming to reduce FLW by Small and Medium-sized Enterprises (SMEs). We investigate which features of a monitoring tool would facilitate SMEs to start measuring FLW and to what extent these are covered by current tools. In our analysis we compare 15 tools and identify 108 different features. Besides an overview of these FLW monitoring systems, our paper addresses important methodological problems in monitoring and delineating food waste, which aims contribute to new standardized methodologies for FW monitoring. In the end, this project should lead to a food production and supply system that monitors its own loss and drastically reduces its waste streams.

Paper ID: 450

Towards a circular economy for mixed waste plastics: A comprehensive evaluation and multi-objective decision-making framework for recycling technologies

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Abstract:
The rapid growth in plastic consumption continues to place significant pressure on natural resources and exacerbates environmental pollution. Recycling technologies have advanced rapidly as crucial solutions to reverse the linear consumption model and promote the development of a circular economy. However, their applicability is often debated due to constraints such as resource consumption, cost limitations, and environmental impacts, particularly in real-world scenarios involving mixed waste plastics. To address the challenge of aligning recycling technologies with mixed waste plastics in pursuit of sustainable circular economy goals, our study systematically reviews research articles in the field of plastic recycling from 2000 to the present. We discuss the difficulties and causes of matching these technologies to mixed waste plastics from the perspectives of both the intrinsic properties of plastics and the recycling technologies themselves. Furthermore, we track the progress of existing evaluation methods, indicators, boundaries, and conclusions to analyze the current research landscape and future development needs. Based on innovations identified in evaluation metrics concerning resource sustainability and health risks, we finally propose a five-dimensional evaluation matrix encompassing environmental, technological, economic, sustainability, and health aspects. This matrix is integrated into a multi-objective decision-making framework to guide the applicability of recycling technologies in complex scenarios.

Paper ID: 452

Mining and social responsibility: assessing the role of community investment

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Abstract:
Company-community relationships are increasingly seen as vital tools for promoting local development. These relationships often take the form of provisions for income distribution, local investments, environmental protection, and socio-economic development. Historically perceived as transactional, the substantial financial commitments—up to 1-2% of revenue—highlight their potential for significant community impact. However, there is a pressing need for robust evaluation systems to measure the socio-economic outcomes of these investments. In the realm of critical minerals, the role of governments in ensuring a sustainable supply chain has been emphasized, while the contributions of private companies and their Corporate Social Responsibility (CSR) efforts have received less attention. Achieving local acceptance and maintaining a Social License to Operate will become increasingly important as demand for minerals grows. Governments and companies must navigate complex local dynamics, address environmental and social concerns, and foster long-term agreements to support a fair energy transition. Data from 42 mining companies, including members of the International Council on Mining and Metals (ICMM) reveals inconsistencies in how social and community investments (CSI) are defined and reported. From 2018 to 2022, CSI as a percentage of EBITDA varied, with companies reporting between 0.1% to 4.7%, and an average between 0.7% and 1.1%. While CSI as a percentage of revenues varied between 0.01% and 1.97% with an average between 0.33% and 0.44%. Significant events, like the Brumadinho dam disaster and the COVID-19 pandemic, influenced these investments. However, detailed reporting on CSI projects remains limited, with inconsistencies in the types of projects funded and their measurable impacts. This underscores the need for improved transparency and evaluation to ensure these investments effectively contribute to local development.

Paper ID: 453

Quality and Transparency in Sustainability Reports: Insights from the Chilean Copper Industry

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Abstract:
Over the past decade, environmental and social challenges have increasingly come to the forefront within the mining sector. In contemporary contexts, transparency within extractive industries is considered indispensable, and proactive engagement with stakeholders to address their concerns has become essential. Sustainability reports serve as a critical instrument for companies to demonstrate their performance in these areas. Employing the Global Reporting Initiative (GRI) standards as a framework, a methodology was developed to evaluate the quality of economic, environmental, and social dimensions reported by copper mining companies in Chile for the years 2021 and 2022. Although there has been a notable enhancement in the volume of reporting, the overall quality of the disclosed information remains suboptimal. There exist substantial opportunities to improve the transparency of the reported data, to elevate the rigor of third-party validation processes, and to refine international mining standards to better address these concerns.

Paper ID: 455

Preliminary Study of Heavy Metal Pollution on the Western Side of the Madura Strait, Indonesia

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Abstract:
Heavy metal contamination has become widespread, particularly in marine ecosystems. One area at risk of heavy metal pollution is the western side of the Madura Strait, Indonesia. This study aims to assess the levels of heavy metal contamination, specifically arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), and lead (Pb), in water and sediment samples from the western side of the Madura Strait, Indonesia. Samples were collected from three locations on the Madura side and three on the Surabaya side. The concentrations of these metals were compared against Indonesian water and sediment quality standards. Results indicated that in both water and sediment, the levels of As, Cd, Cr, Cu, and Pb exceeded the regulatory thresholds, with the highest concentrations observed in sediment samples from Surabaya (Sby 3). These findings suggest that the Madura Strait is experiencing concerning levels of heavy metal pollution, which may pose risks to aquatic ecosystems and human health. Further research is required to determine the sources and potential ecological impacts of this contamination.

Paper ID: 456

Enhanced heavy metal adsorption using biochar derived from Solidago canadensis and agricultural residues: Mechanistic insights and application potential

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Abstract:

The application of biochar for the remediation of heavy metal contamination in the environment has gained significant attention in recent years. This study focuses on the production of biochar from invasive plant species and agricultural residues, highlighting its dual benefits: reducing disposal costs and providing economic value. Specifically, biochars were produced from the stems of Solidago canadensis and peach trees, as well as from rice straw, corn stems, and walnut shells, through pyrolysis at 600 °C. The physicochemical properties of these biochars were systematically characterized. In adsorption kinetics experiments, biochars labeled as SB (Solidago canadensis stem), PB (peach tree stem), RB (rice straw), CB (corn stem), and WB (walnut shell) were introduced into solutions containing Cd^{2+} and Pb^{2+} ions, each at an initial concentration of 10 mg/L. The residual concentrations of these heavy metals were measured at various time intervals to evaluate adsorption efficiency. Additionally, adsorption equilibrium experiments were performed with initial Cd^{2+} and Pb^{2+} concentrations ranging from 0 to 900 mg/L. The kinetics data were modeled using pseudo-first-order, pseudo-second-order, and Elovich models, while adsorption isotherms were fitted to Freundlich and Langmuir models. Advanced analytical techniques, including SEM-EDS, XRD, FTIR, and XPS, were utilized before and after adsorption to elucidate the potential mechanisms underlying the adsorption processes for the five biochars. The findings indicate that biochar derived from Solidago canadensis exhibits superior adsorption capabilities for Cd^{2+} and Pb^{2+} compared to other plant-based biochars, offering promising implications for future applications in environmental remediation.

Paper ID: 460

Circular economy for post-hazard infrastructure restoration: strategies for resilience and resource efficiency

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Abstract:
Climate change, resource depletion, and increasing frequency of natural disasters pose significant challenges to our societies. Transitioning towards a circular economy and making our infrastructure more resilient has never been more urgent. Circular economy research for the built environment focused largely on buildings with limited studies on infrastructure assets and networks. Rapidly restoring essential functionality of damaged infrastructure in the aftermath of natural hazards is of paramount importance and should be done in a resource-efficient manner. Though existing literature on post-hazard repairs is extant and comprehensive, integrating principles of circularity with restoration strategies has yet to be addressed. This research aims to inform infrastructure post-hazard restoration strategies by adopting circular economy principles. The work reviews literature related to damage assessment, damage states, decision-making for repairs, and circular principles suitable for infrastructure. To enable quick decision-making, a post-hazard rapid auditing survey for practitioners is developed, and formulaic expressions for integrating circularity indices for asset recovery are proposed. These are derived from research and validated through practitioners and researchers from different regions. Considering the lack of infrastructure-related circularity research, the findings from this work can be immediately adopted by practitioners interested in using circular strategies for post-hazard asset management. Additionally, the work stands as a reference for academics to further develop frameworks that acknowledge the varying needs of infrastructure resilience planning, promoting both immediate functionality and long-term circularity.

Paper ID: 463

Reducing greenhouse gas emissions in livestock farms: A resource orchestration theory perspective on total resource management

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Abstract:
This study applies resource orchestration theory (ROT) to explore total resource management (TRM) as a strategic approach to reducing greenhouse gas emissions in livestock farms. While TRM offers a promising solution for enhancing environmental sustainability, the identification and interrelation of TRM attributes specific to emission reduction have not been thoroughly examined. This research aims to determine the TRM attributes, explore their interrelationships, and highlight areas for performance improvement. A hybrid methodology combining the fuzzy Delphi method and the fuzzy Decision-Making Trial and Evaluation Laboratory (FDEMATEL) is employed to analyze these attributes. The study identifies that energy efficiency, livestock genetics and breeding, valorizing waste streams, and land use and grazing management are key drivers. At the same time, feed management and stakeholder engagement emerge as significant effects. For practitioners, the criteria for improvement include feed additives, nutrient management, carbon-neutral feed production, and the engagement of farmers and local communities. The findings provide actionable strategies for optimizing resource use and reducing greenhouse gas emissions in livestock farms, advancing the sustainability of agricultural practices.

Paper ID: 465

Performance Evaluation and degradation assessment of Photovoltaic (PV) modules- A State-of-the-Art Review

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Abstract:
In the present-day data-driven era, machine learning, deep learning, big data, statistics, image processing and data science are essential for forecasting outcomes and getting insights from data. For the same, the major unending source of electricity is made available by the deployment of photovoltaic technology. Noticeable damages have affected the performance and energy efficiency of the photovoltaic modules. Monitoring the Photovoltaic modules for fault detection over a larger area is the thrust area of todays research. So, the present work focuses on a comprehensive literature survey to study and identify the problem of faults like hotspot formation and highlight the alternatives for its mitigation through the reported case histories. A three-step method is applied for the study wherein the literature is surveyed in depth on identifying and prioritizing the faults followed by discussing the fault mitigation techniques at length. From the study, it is noted that manual and traditional monitoring methods as in the case of smaller are not a suitable alternative in the ever-increasing demand for the use of renewable energies for a sustainable future. Secondly, to detect faults like hotspots, etc. Hough line detection and canny edge detection methods are used which have their limitations when the arrangement of PV modules is irregular at critical locations like rooftops, mountains, etc. Considering the constraints and identifying the gaps from the available studies it is proposed to use advanced deep learning-based algorithm techniques for monitoring the PV modules.

Paper ID: 466

Refuse-derived fuel (RDF) in the world and Brazilian context: a bibliometric and systematic review

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Abstract:

Refuse-Derived Fuel (RDF) is a product from Municipal Solid Waste (MSW) with potential for use in energy generation. However, it is noted that there are aspects related to RDF that need to be better understood. The literature review is essential as it allows the validation of studies already carried out and indicates paths for new work that covers existing gaps. Thus, this review aimed to obtain quantitative and qualitative information regarding RDF in Brazil and around the world. A systematic search of works was carried out using the terms “Refuse-derived fuel” or “Refuse-derived fuels” or “Refuse derived fuel” or “Refuse derived fuels” on the Web of Science platform within a period of 30 years (1994 – 2023). A total of 774 files were eligible for the bibliometric review and 263 files for the systematic review. VOSViewer was used to analyze the bibliometric data. The abstracts were read for the systematic review. As a result, it was observed that, on the global scenario, files are distributed with exponential growth over time, with 40.70% concentrated in the last five years (2023 - 2019). This demonstrates an increase in interest in the topic. Japan is the country with the highest number of publications (72). In the Brazilian scenario, it was observed that the topic is recent (since 2016), with only 16 works. The main categories in which the works are distributed are: Environmental Sciences and Energy Fuels. It was observed that the main themes involving RDF are present throughout the period: characterization, logistics analyzes (technology and processes), waste management and co-combustion and co-pyrolysis of RDF with coal and biomass. It was concluded that significant information was gathered, including the global relevance of the topic, Brazil's positioning, existing research gaps, and other key insights. These data will serve as a basis for future research.

Paper ID: 467

Potential of utilizing recycled PET fibres and agricultural waste as sustainable & economical Alternative in fibre reinforced concrete

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Abstract:
Fibre reinforced concrete (FRC) composites have been widely utilised in construction for a number of years to improve the performance of structural concrete. Incorporating agricultural/ industrial waste into the construction industry as FRC composites is a novel research field that can recycle and convert waste into valuable supplementary materials. In this study, concrete composites with fibres of coconut coir (CCF), wheat straw (WSF), and shredded fibres from waste plastic bottles (PETF) were evaluated and compared against the established use of polypropylene fibres (PPF) and steel fibres (SF). The study's objectives were set to attain the strength of 32-40 MPa (C32/40 grade) for using these waste fibres as alternatives in FRC. A concrete mix ratio of 1:2:3 with 1-2% waste fibres (CCF, WSF & PETF), 1-2% PPFC and 10% & 17% steel fibres were used to produce samples for testing on 7 & 28 days for evaluation of compressive, split tensile and flexural strengths. Generally, all FRC mixes with 1% fibre dosage exhibited an increase of compressive strength by 9 - 44% at 28 days. All fibre composites gave characteristic compressive strength of 40-60 MPa. Both the split tensile and flexural strength of all-fibre composites were generally improved with 1-2% fibres. flexural strength suggesting that fibre content should not exceed more than 2% of cement weight in composites. Shredded fibres of PET plastic bottles outperformed the established micro/macro PPF as PETF exhibited better flexural strength than PPF with both 1 and 2% dosages. The natural fibres of coir/wheat straw performed favourably compared to steel fibres (6.9 MPa). In conclusion, it is suggested that the optimum quantity of 1-2% of these novel alternative fibres after necessary treatment is feasible for the formulation of environmentally friendly fibre concrete composite with enhanced mechanical properties.

Paper ID: 468

Enhanced lithium phosphate granulation and separation from industrial lithium-impacted wastewater by continuous fluidized-bed crystallization process

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Abstract:

This work demonstrates a novel, systematic and sustainable route for the lithium recovery from industrial lithium–impacted wastewater. First time, lithium was selectively recovery using batch stirred and fluidized-bed homogeneous crystallization systems. The trisodium phosphate was applied as precipitants to form lithium phosphate (Li3PO4). In the batch stirred system, the removal efficiency of Li+ and PO43- reached the optimum condition of 98.5%, and 99.1%, respectively, under the operating conditions of pH 11.5 ± 0.2, temperature of 75°C, a 25 m/h up–flow velocity and an [Li]/[P] ratio of 1.25. In the same operating conditions, the crystallization ratio (CR%) and total removal (TR%) of the C-FBHC system reached 93.2% and 99.1%; 71.2% and 95.6% for Li+, and PO43−, respectively. The XRD, Raman, FTIR and SEM-EDX analysis confirmed that Li and PO4 were crystallized as Li3PO4 solid product with a purity greater than 95 ± 3% and an average particle size of 0.5 mm. However, the water content of the C-FBHC product is much lower than that of the batch-stirred system (6.8% and 92.3%, respectively). The increase in total suspended solids resulted in not only decreases in the removal efficiency and Li3PO4 purity but also an irregular morphology in the Li3PO4 crystals. Furthermore, increasing the Na concentration significantly reduced the crystal size of the pellets. The optimal up-flow velocity should be 1.5–2.4 times the minimum fluidization velocity (12.75 m/h) to create many new uniform crystals and increase the lithium removal rate by 5–10%. A cost-benefit estimation of actual industrial lithium-impacted wastewater treatment indicated a profit of approximately USD 22/m3–industrial Li-impacted wastewater. The overall study confirmed the suitability of the developed scheme for industrial application to provide economic and environmental benefits. Green chemistry metrics and the revenue generated from the developed process were calculated which revealed that the process is indeed green, sustainable, and economic.

Paper ID: 469

A framework for developing a Deconstruction Information Modeling planning system for Circular Economy in the built environment

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Abstract:
The construction industry faces a significant sustainability crisis, driven by high levels of resource depletion, greenhouse gas emissions, and waste generation. As urban infrastructure continues to expand, there is an urgent need to transition from a linear economy to a Circular Economy (CE) to address these environmental challenges. This research proposal aims to advance the implementation of disruptive technologies, including Building Information Modeling (BIM), Digital Twins (DT), Digital Material Passports (MP), and Artificial Intelligence (AI), to enhance building disassembly processes and support CE principles. The study will develop a comprehensive BIM-based disassembly management system that integrates these technologies to optimize selective disassembly planning (SDP) and promote material recovery, reuse, and recycling throughout the building lifecycle. The proposed methodology involves five phases: (1) conducting a literature review to identify gaps and best practices; (2) designing a BIM-based framework incorporating Deconstruction Information Modeling (DIM) and SDP; (3) developing specialized software for disassembly planning and integrating DT and MP for real-time monitoring and traceability; (4) implementing AI algorithms to automate and optimize disassembly processes; and (5) validating the system through case studies and developing guidelines for industry adoption. The research will leverage existing SDP methods, enhancing them for complete building assessments by considering building subsystems and layers of change. By integrating AI-based search algorithms and automation tools, the study aims to improve decision-making, efficiency, and sustainability in building disassembly and deconstruction. The results will contribute to the broader adoption of CE practices in the construction industry, addressing global resource constraints and supporting environmental sustainability.

Paper ID: 470

A life cycle assessment on fast food meal packaging: A case study on burger combo packages in Canada

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Abstract:
The extensive consumption of fast-food meals in North America continues to generate substantial packaging waste. This study aims to assess the environmental footprints of multiple packaging formats and materials used for burger combos in five leading fast-food burger chains in Canada. In this context, a burger combo includes one burger, fries, one medium-sized soft drink, and sauce. A life cycle assessment (LCA) was conducted on current market options for burger combos on fast food menus to assess the environmental performance of each packaging component within the combo. The scope of the LCA included the entire life cycles of the packages. The life cycle inventory included the foreground data obtained from direct sample analyses and the background data from USLCI, and US-EI 2.2. TRACI 2.1 including ten impact categories was used as the life cycle impact analysis method. For the burger, the LCA results indicate that composite materials such as the laminated aluminium wrap are especially environmentally taxing as they frequently demand more energy, which is obtained from fossil fuel resources. For the fries, the polyethylene terephthalate (PET) lined paperboard cup has the larger environmental impact than the kraft paper sleeve and the paperboard cup. Among drink packaging options, the plastic PET bottle performs the worst across eight out of the ten impact categories. Contrary to current consumer perceptions, the paper straw when compared to the plastic straw performs worse across eight out of the ten impact categories. Consolidating the components into a larger all-encompassing piece of packaging would be a means of achieving this mitigation. Alternatively, a hypothetically environmentally friendlier combo packaging can be created by combining a specific set of pre-existing packaging components chosen based on the results of this study.

Paper ID: 476

The impact of UV radiation, a consequence of climate change on phenotypic and molecular changes of wheat (Triticum durum)

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Abstract:
Human activities play a major role in depletion of the ozone layer that leads to a significant increase in the amount of ultraviolet radiation that reaches the earth's surface. This affects plant's growth and development. On the other hand, plants showed different responses to UV radiation either in growth, morphological changes or productivity. In this study, we examined the effect of UV-B on wheat (Triticum. durum) seedlings growth characteristics, biochemical contents and expression of Dehydration responsive element binding protein (DREB) which is considered as a major group of transcription factors involved in abiotic stresses tolerance. Wheat seedlings (14-day-old) were exposed to 30, 60 and 90 min of UV-B irradiation. Results showed that UV-B reduced significantly shoot and root length, leaf number. Seedlings exposed to 90 min of UV-B showed the highest % of leaf damage. Furthermore, proline and LPO content increased by UV-B irrradiation. DREB RT-qPCR analysis showed that expression levels of TaDREB3 and TaCBF5L were upregulated under UV-B. on the other hand, expression levels of DREB6 decreased significantly by UV-B.