International Workshop
Advances in Cleaner Production
Coupling Green to Blue Economies
November 13th - 15th 2019  Sanya, China
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Welcome to 8th International Workshop – 2019 Advances in Cleaner Production
When the United Nations made “Green Economy” a major theme of the Rio+20 world summit in June 2012, it referred to concerns beyond terrestrial. On the way to Rio+20, many coastal cities started promoting “Blue Economy”, which is focused on the marine environment. “Blue economy” is a “green economy” that prominently features oceans, which account for almost 71 percent of the earth’s surface. More concerns of coastal cities are increasing their share of benefits from the use of their marine living resources and building the resilience of marine ecosystems to the impact of climate change and ocean acidification.

Although various countries have different priorities—blue, brown, gray, and, of course, green, etc. that represent varied types of concerns—there is general acceptance that nature must be at the center of a green economy. Thus, building the resilience of nature, improving governance of natural resources, and mainstreaming ecosystem values must be prominent in a green economy plan.

From Green to Blue Economy offers a fresh perspective on the environmental challenges that cities face, along with the opportunities and barriers to going green or blue and fostering economic growth. Cleaner Production has been applied realizing targets of Sustainable Development coinciding e.g. with the aims of public health and clean environments as they are interpreted in a green and smart city context (neutral carbon balance, zero waste, accessible green and blue spaces), and development in general. To this end major changes and innovation will be necessary.

This international conference aims to provide an opportunity to academic and decision-making professionals to discuss recent progress in Cleaner Production technology, implementation of green policies, and development of blue economy. It provides a comprehensive overview of the experiences of cities around the world as they make the transition to a green and blue economy.

We are looking forward to meeting you in Sanya, China

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Henrik Lund (born 2 July 1960) is a Danish engineer (M.Sc.Eng,1985) and Professor in Energy Planning at Aalborg University in Denmark. He holds a Ph.D. in Implementation of Sustainable Energy Systems (1990), and a Dr. Techn. in Choice Awareness and Renewable Energy Systems (2009).

Henrik Lund is a highly ranked world-leading researcher. He is listed among ISI Highly Cited researchers ranking him among the top 1% researchers in the world within engineering.

Henrik Lund has many years of management experience as head of department for approx. 200 staff persons (1996-2002), head of section for approx. 50 persons (2014-2016) and head of research group of 20-30 persons (2002-present). During his time the Sustainable Energy Planning research group at Aalborg University has now grown to approx. 30 staff members including 5 professors.

Henrik Lund is Editor-in-Chief of Elsevier’s high-impact journal Energy with annual 8000+ submissions.

Henrik Lund is the author of more than 400 books and articles including the book "Renewable Energy Systems". He is the architect behind the advanced energy system analysis software EnergyPLAN, which is a freeware used worldwide that have form the basis of more than 100 peer reviewed journal papers around the world.
Renato Boero is the chairperson of Iren S.p.A. since May 2019, he graduated in Electrotechni-
cal Engineering from Turin Polytechnic. A technical engineer, he acquired considerable
experience at ENEL in the field of management of complex energy production plants in Italy
and abroad. For eight years, from 2007, he worked in the waste management sector in Milan
at AMSA and A2A, dealing with environmentalist of the Sillaz waste-to-energy plant,
management of waste processing plants, landfills, reclamations, management of permitting,
construction and start-up of the glass processing plant for transformation into product of the
separate glass collection in Milan. Since 2016, he has been Chairperson and a member of the
board of Iren Energia, and Chairperson and a member of the board of TRM, a waste process-
ing company in the Turin Metropolitan Area. He is a member of the Executive Committee of
Utilitarian.
Ming Xu

University of Michigan
Editor-in-Chief of Resources Conservation & Recycling

Dr. Ming Xu is an associate professor in the department of natural resources and environment and civil and environmental engineering at the University of Michigan.

Professor Xu received his bachelor’s and master’s degrees in environmental science and engineering from Tsinghua university in 2003 and 2006 respectively, and his doctoral degree in civil and environmental engineering from Arizona state university in 2009. He was a postdoctoral researcher at Georgia institute of technology from 2009 to 2010. From 2010 to 2016, he was an assistant professor of natural resources and environment and civil and environmental engineering at the university of Michigan.

The research direction is trade and environment, life cycle assessment, big data and data mining applications in the field of environment. He is currently director of the international society for industrial ecology and editor-in-chief of Resources, Conservation & Recycling. For his outstanding contributions in the field of industrial ecology, Dr. Ming Xu was the first Chinese recipient of the international society for industrial ecology Laudise award in 2015. In 2016, he won the national science foundation’s highest award for young teachers, CAREER. In 2017, he won the Chinese American association of environmental engineering and science professors’ award for cutting-edge research. He is currently a visiting professor at Tsinghua university, Peking University, Chinese Academy of Environmental Sciences and DE La Sala University in the Philippines.
Lu Ding

Tokyo Institute of Technology

Dr. Lu Ding is now an associate research fellow in Institute of Clean Coal Technology, East China University of Science and Technology. He has published over 40 journal papers. Two journal papers were ESI Highly cited papers, and another one paper was ESI hot paper. His research profile covers the following aspects:

1. Solid waste treatment by using hydrothermal technology for producing fuel, activated carbon, or fertilizer.

2. Biomass/coal gasification and power generation

3. Application of catalysis in producing high value chemicals and fuels from biomass materials

4. CO$_2$ capture and storage

Dr Ding is devoting to the triad solution for independent energy production, and urban biomass waste treatment, and CO$_2$ reduction.
Sergio Ulgiati has expertise and research interests in Energy Analysis, Environmental Accounting and Emergy Synthesis, Life Cycle Assessment, Sustainability indicators, Evaluation and impact assessment of renewable and nonrenewable energy systems. In most recent years his research activity expanded to the evaluation of options for zero emission technologies and strategies (ZETS) also by means of sustainable biotechnologies applied to agricultural and agro-industrial processes. Ulgiati is member of the Editorial Board of the International Journals of Energy, Ecological Modelling, Ecological Economy, and Environment, Development and Sustainability. He is also guest Editor of the Journal of Cleaner Production for a Special Issue on “Zero Emissions Technologies and Systems” (January 2007), with more than 200 papers and Chapters published in international Journals and Books. He is president 2010-2012 of ISAER - The International Society for the Advancement of Emergy Research.
Weslynne Ashton is an Assistant Professor of Environmental Management and Sustainability at the Illinois Institute of Technology (IIT) Stuart School of Business. Her research focuses on two core areas: industrial ecology, industrial symbiosis and collaborative approaches to environmental management, and sustainability strategies for small and medium enterprises (SMEs) and new ventures. She teaches courses in Industrial Ecology, Business Sustainability, and Social Entrepreneurship across business, public administration and environmental management programs. She strives to develop business solutions to social and environmental challenges in low income and developing regions through her research and teaching. She currently leads the “Pathways to Cleaner Production in the Americas” project - an eight country, interdisciplinary partnership focused on education for cleaner production (CP) and its implementation in small and medium enterprises in Latin America.

Prior to IIT, Weslynne led Yale University’s “Industrial Ecology in Developing Countries” program where she trained researchers and graduate students in South and Southeast Asia in IE concepts and methods, holding visiting faculty appointments at TERI University in India and the National University of Singapore. She was a consultant on CP promotion strategies for the Inter-American Development Bank, and also worked as an environmental engineer and technology entrepreneur. She has a bachelor’s degree in Environmental Engineering from the Massachusetts Institute of Technology, and master’s and doctoral degrees in Environmental Science from Yale University’s School of Forestry and Environmental Studies. She is originally from Trinidad and Tobago in the Caribbean, and lives in Chicago, USA.
Yutao Wang is the younger researcher of Fudan university, Journal of Cleaner Production Executive Editor, member of Chinese ecological society, the ecology association, member of the international industrial ecological society, the national ecological economic society member, the first Chinese ecological society ecosystem services, international partners, was once the city green resources recycling engineering, Tsinghua university research center researcher. Nearly five years successively presided over by the national natural science foundation of China, China postdoctoral science foundation special subsidy and on finance, the ministry of land and resources, such as national, provincial level topic more than ten items, the Applied Energy, Journal of Cleaner Production, Scientific Reports, Ecological Indicators published more than 40 papers, national natural science fund letter of evaluation experts.
Cecília M.V.B. Almeida

Paulista University
Editor-in-Chief of Journal of Cleaner Production

Cecília is Full professor of Institute of Exact Sciences and Technology and of Graduation Program on Production Engineering in Paulista University. She develops researches on areas of Cleaner Production and Industrial Ecology in which concepts, tools and techniques for the calculation of environmental indicators and sustainability indicators are analyzed and developed.

Cecília is also a researcher in the Production and Environment Laboratory (LaProMA) in Paulista University. From 2012 to 2015 she served as Subject Editor: Cleaner Production in Latin America for the Journal of Cleaner Production, in 2016 she served as Executive Editor and since May 2017 is Co-Editor-in-Chief of the Journal of Cleaner Production.

She holds a bachelor’s degree in Chemical Engineering from Universidade Presbiteriana Mackenzie (1983), a Master’s degree in Chemistry (Physics and Chemistry) from the University of São Paulo (1995) and a Ph.D. in Chemistry (Physics and Chemistry) from the University of São Paulo (1999).
Giovanni Baiocchi

Maryland University
Associate Editor of Journal of Cleaner Production

Dr. Giovanni Baiocchi is an applied environmental economist. Giovanni’s main research looks at the global and local impact of economic activity, including trade, urbanization, and lifestyles.

He has published a wide range of interdisciplinary research in international multidisciplinary journals such as Environmental Science & Technology, Ecological Economics, Journal of Industrial Ecology, Nature Climate Change, and Computational Economics. Giovanni is a lead author for the IPCC 5th Assessment for Working Group III, focusing on the drivers, trends, and mitigation of climate change. He was also selected as a qualified independent expert for environmental themes by the European Commission.
Gang Liu is the associate professor of Southern Denmark University. He is the vice President of the social and economic metabolism branch of the international society for industrial ecology and the council member of the Chinese society for industrial ecology. He is mainly engaged in research on industrial ecology, material flow and resource and environmental management. More than 40 papers have been published in Nature Climate Change, Environmental Science & Technology, etc. He is the deputy editor of Resource, Conservation and Recycling of SCI journals, editor of Journal of Cleaner Production and Sustainability, and project leader of several European Union, Denmark and Norway scientific research projects. He has been invited as a consultant expert for international organizations such as the UN food and agriculture organization, the European Union joint research center.
Prof. Linda Hancock holds a Personal Chair in Public Policy at Deakin University in Melbourne, Australia at the Alfred Deakin Institute for Citizenship and Globalisation and researches on public policy analysis, applied social policy, regulatory theory global governance, CSR and the social, ethical and political implications of new technology; in particular, corporate-government relations.

She has held seven national Australian Research Council (ARC) research grants and is currently working on two including the ARC Centre of Excellence for Electromaterials Science (ACES) on the Ethics, Policy and Public Engagement team.

She has held three Ministerial appointments as: Law Reform Commissioner (Government of Victoria); Presiding Member, Social Security Appeals Tribunal (Government of Australia) and International Regulatory Advisory Panel (Government of Singapore).

International posts include Head of Research (Responsible Gambling Fund) UK and advisor to the Nova Scotia government (Canada). She is a regular reviewer of ESRC Research applications and reports (UK); Australian Research Council applications and research applications for five Canadian province research funding bodies; in addition to journal reviews including Journal of Cleaner Production.
Lei Shi

Tsinghua University
Associate Editor of Resources Conservation & Recycling

Lei Shi is the associate professor, school of environment, Tsinghua university; director of the Tsinghua branch of the national key laboratory of ecological industry for environmental protection; director of the Asia office of Journal of Industrial Ecology; deputy editor of Journal of Cleaner Production; chairman of the 10th international conference on Industrial Ecology (2019); director of the professional committee of Industrial Ecology of China ecological society. Engaged in industrial ecology study, the main interests include industrial ecological system complexity, substance metabolism and ecological innovation, host and participate in more than 40 topics, including the national natural science fund "based on the complex network of industrial ecology evolution mechanism analysis and system simulation" and the national social science fund "China theory and empirical research of ecological economy development model", etc., nearly hundred academic theses being published.
KEYNOTE SPEECHES
100% Renewable Smart Energy Systems

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Abstract

This presentation elaborates on the concept of Smart Energy Systems and present a case of applying such concept to the design of a 100% renewable energy future for a local community in Europe by 2050. Aalborg in Denmark is used as a case and the study focus on how such a local community are to be seen as part of the Danish as well as the European overall strategies.

In recent years, the terms “Smart Energy” and “Smart Energy Systems” have been used to express an approach that reaches broader than the term “Smart grid”. Where Smart Grids focus primarily on the electricity sector, Smart Energy Systems take an integrated holistic focus on the inclusion of more sectors (electricity, heating, cooling, industry, buildings and transportation) and allows for the identification of more achievable and affordable solutions to the transformation into future renewable and sustainable energy solutions.

It is often highlighted how the transition to renewable energy supply calls for significant electricity storage. However, one has to move beyond the electricity-only focus and take a holistic energy system view to identify optimal solutions for integrating renewable energy. In this presentation, an integrated cross-sector approach is used to argue the most efficient and least-cost storage options for the entire renewable energy system concluding that the best storage solutions cannot be found through analyses focusing on the individual sub-sectors. Moreover, such approach leads to a solutions primarily based on existing energy infrastructures rather than leading to significant extra investments.

The presentation presents a set of methods and criteria to design Smart Energy Cities, while taking into account the context of 100% renewable energy on a national level. Cities and municipalities should handle locally what concerns local demands, but acknowledge the national context when discussing resources and industrial and transport demands. To illustrate the method, it is applied to the case of transitioning the municipality of Aalborg to a 100% renewable Smart Energy System within the context of a Danish and European energy system.
Life Cycle Thinking for Decision Support in Cleaner Production

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Abstract

Life cycle thinking and life cycle assessment (LCA) evaluate environmental impacts of a product system from its entire life cycle, from raw material acquisition to end-of-life. This presentation shows how life cycle thinking can help support decisions in cleaner production research and practices. It will also discuss critical challenges facing LCA research and practices. Specifically, one of the challenges is missing data. Due to lack of primary data or high cost of collecting primary data, LCA studies often need to make unrealistic assumptions, leading to inaccurate results. To address this challenge, we have developed new computational methods using data science tools to estimate missing data in LCA solely relying on limited known data. This work provides a new direction to obtain data for LCA and demonstrates a promising potential of using data science approaches for LCA data compilation. Developing sophisticated data science tools for LCA will help promote the application of life cycle thinking in cleaner production decision-making.

Clean solid biofuel production from high moisture content biomass waste by employing hydrothermal treatment technology

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Abstract

Reducing the dependence on fossil fuel is a common social challenge all over the world. Biomass is unique among renewable energy sources because it can be used to produce solid and liquid fuels with conventional conversion pathways in chemical industries. Wet biomass (organic waste and
sewage sludge) is a partially unutilized resource with very low fuel price, if not zero or negative, in the market. However, such biomass is hard to utilize due to high moisture and ash content as well as low density. Hydrothermal treatment technology (HTT) is an efficient pretreatment technology for solid biomass wastes to increase density and heating value and to decrease moisture content which employs saturated steam as a media for the different degrees of hydrolysis as well as mechanical destruction of cell walls. The treatment begins by loading raw material into a reactor, followed by steam injection into the reactor. Mixing is then conducted by a stirrer in the reactor, while maintaining the temperature and pressure.

In this study, HTT processes of typical biomass wastes (municipal solid waste (MSW), sewage sludge (SS), and rice straw (RS)) were carried out for biomass hydrochar preparation using 3 L hydrothermal reactor. MSW was composed of chicken meat, wood waste, bread, cheese, and plastics, which was the common waste components in Japan. Moisture content in MSW, SS, and rice straw were around 20 wt.%, 80 wt.%, 15 wt.%, respectively. Effects of varied holding time (5min, 15min, 30min) and different final temperatures (160 °C, 180 °C, 200 °C, 220 °C, 240 °C) on HTT processes and the corresponding solid fuel characters were compared MSW. The results showed that feedstock type, reactor pressure and holding time at the target temperature are three key factors affecting the solid solubility and dewatering efficiency after HTT process. Solid solubility for all the feedstock increased with HTT pressure and holding time, which was not favorable for realizing high solid fuel yield. The lowest temperature and pressure conditions for the powdered fuel production from MSW and RS were 200 °C and 1.4 MPa, and 220 °C and 2.4 MPa, respectively, while HTT of SS could produce powdered solid even at low temperature and pressure of 160 °C, 0.7 MPa. It is noted that the dewatering efficiency by using vacuum filtration system of SS decreased dramatically with decreasing HTT temperature, and showed worst at 160 °C (240 °C > 220 °C > 200 °C = 180 °C > 160 °C). Moreover, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of waste water after HTT all increased with increasing HTT temperature for all the feedstock, while the liquid PH after the HTT process and the reactivity and the lower heating value of solid fuel showed opposite trends. In conclusion, considering the solid fuel characters and HTT process efficiency, the optimal powdered HTT products formed at 200 °C and 1.4 MPa, 180 °C and 1.1 MPa, and 220 °C and 2.4 MPa for MSW, SS, and RS, respectively.

**Keywords**

hydrothermal treatment; biomass wastes; solid fuel
Overcoming the asymmetry between urban and rural systems. Towards fair exchange and appropriate use of environmental and human capital.

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Abstract

Modern cities are living organisms that need a continuously greater amount of resources. Like any organism, most of the resources are taken from the outside: from both the immediately surrounding environment (ecosystem services), and suppliers in a wider range. A city sustainability cannot be assessed by only considering the city itself, but requires that focus is also placed on the surrounding rural environment (forests, countryside, industrial parks), so that the complex dynamic urban-rural is looked at for comprehensive assessment. In particular, focus needs to be placed on the asymmetric relation between urban and rural environments, with more ecosystem services being provided to urban environment and very little support (as reversal feeding) being provided to rural areas, to compensate its services and to preserve its integrity and the quality of life of rural population. Inflows are processed within city sectors (transportation, households, energy, social, health services, among others) and generate waste flows characterised by potential impacts. This lecture aims at: listing inflows and outflows, assessing how resources are processed inside the city’s structure (urban metabolism), understanding to what extent these flows are generating welfare, wellbeing and/or environmental degradation, selecting purposefully tailored assessment methods and indicators of performance, identifying hotspots and bottlenecks related to quality of life and environmental integrity. In summary, this can be done by addressing aspects of urban and rural quality of life and by creating scenarios for suitable lifestyle changes, community services, and/or mitigation actions aimed at a more stable and productive interplay of urban and rural environments. Scenarios include proposals for re-ruralization and greening of cities (urban gardens, green architecture, green roofs and facades), urban biodiversity, reforestation, solarization of urban and rural degraded areas. None of these aspects can be properly addressed without implementing a joint strategy that involves stakeholders at all levels from monitoring to solution design (participatory surveys and synergic coupling of top-down and bottom-up strategies towards agreed upon evaluations and designs for smart urban/smart rural living). A truly
sustainable city development should minimize its negative feedback to the "rural outside" and support the "rural inside", by implementing and promoting circular economy mechanisms. In this way, on the one hand there would be a rebalancing at local scale of input and output streams, necessary to pursue a fair global redistribution of social welfare; on the other, economic and environmental efficiency enhancements would emerge, by reducing the distance between supplier and user (rural environment and the city) which is now one of the main causes of environmental and quality of life losses.

**Building Regenerative Economies for People and Planet**

Weslynne Ashton

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**Abstract**

We live in an unprecedented period in planetary history, as the scale, speed, and scope of human economic activities threaten the survival of human and most other species on earth. Recognizing that our linear economic models need to change to enable all life to flourish, scholars and practitioners are exploring alternative “economies”. Among these efforts are the “green” – focused on environmentally benign practices for life above water, the “blue” – harnessing while protecting ocean resources, and “circular” – creating closed loops that can regenerate resources. Each of these economies promote the conservation of resources in line with planetary boundaries. Generally, these movements discuss the responsibility of organizations in promoting changes, and the role of humans as actors leading these changes. Although enhancing human outcomes such as equitable distribution of wealth and improved quality of life are mentioned, they have not been a priority in defining intervention strategies for current economic models. On the other hand, the “solidarity” economy is grounded in human and social well-being, beyond individual profits and towards self-determination, equity and the creation of multiple types of benefits for diverse actors; while “doughnut” economy seeks to define a safe space for economic activity based on minimum social needs and maximum perturbation of planetary boundaries. All of these re-conceptualizations point towards creating economic systems that no longer exploit resources for the benefit of relatively few humans, but instead regenerate different types of capital in order to more equitably benefit human actors, other species and ecosystems.

Working at the intersection of sustainability science, industrial ecology and design, we have developed frameworks, models, and tools to create a new approach for considering a variety of resources that diverse human agents utilize when creating value for themselves, society and the planet. We utilized the concept of capital as resources capable of producing other resources,
and delineated eight types currently used in modern socio-ecological-technical systems (SETS): natural, financial, manufactured, digital, human, social, political, and cultural. We used participatory action research and prototyping methods to integrate knowledge distributed across multiple levels in these systems, then applied and tested our approach with individual firms (micro level), among a group of firms (meso level), and across a region (macro level). Each application supported processes for co-creating intervention strategies with a diverse group of stakeholders, and focused on the potential these stakeholders have to regenerate different types of resources through economic activities that serve a broader constituency, including a diverse group of people and the planet. In this talk, I highlight three of the cases – single facility (loop closing), group of firms (industrial symbiosis), region (brownfields as assets), and demonstrate how they contributed to the development of the frameworks. We need massive shifts in how we conceive, develop and manage both hard and soft infrastructures in order to realize regenerative economies that benefit people and planet.

Special Workshop

**Global cleaner production outlook**

Yutao Wang

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**Abstract**

The 20th century has witnessed the most rapid development of human industrialization coupled with the frequency appearance of environmental problems as well. From the famous ten events of environmental pollution to the publication of Silent Spring that awaked people's environmental consciousness, which lead to the environmental movement in 1960s-1970s. The traditional environmental protection strategy was unable to meet the increasing demands for better environmental protection, and to achieve a win-win situation between ecology and economy. As an important measure to deal with environmental pollution, the appearance of cleaner production is the historical necessity of rapid development of human industry. It has been initially developed in North America and Western Europe in 1970s-1980s, and was spread further in other countries especially after 1990s. Cleaner production has made considerable progress both in academic research and practical development. Compared with traditional environmental protection strategies which rely too much on end-of-pipe treatments, CP emphasizes the concept of “prevention is the solution to pollution” which is a paradigm shift from traditional environmental protection strategies. To better
understand the role of cleaner production playing in accelerating the transition to post fossil carbon society, this talk aims to revisit the history, context, and future trends of global cleaner production.

**Cleaner Production (CP) in Latin in the last 40 years**

C.M.V.B. Almeida

Paulista University, 05347-020, Brazil

**Abstract**

Substantial attention has been directed to Cleaner Production (CP) in Latin in the last 40 years. The advancement of CP in the region has been expressly heightened by the establishment of numerous National Cleaner Production Centres (NCPCs) supported by UNIDO/UNEP. Among the key factors that led the regional interest in CP were the need to sustain the industry competitiveness in foreign markets and the need to build a more environmentally friendly industry. At the same time, universities have integrated the approach into their master and doctorate programmes, in the attempt to educate capable professionals for a more sustainable industry/region/country. Leading this group, the Universidade Paulista developed a series of thesis and articles on environmental concerns and launched the International Workshop on Advances in Cleaner Production in partnership with the Journal of Cleaner Production. The workshop achieved its main target that was to establish a multi/interdisciplinary forum for the exchange of information and research results on technologies, concepts and policies based on CP, and as a natural consequence, the Advances in Cleaner Production Network (ACPN) was created to integrate Sustainability Centers and cutting edge academic research. An overview of the CP evolution in Latin America will highlight the steps that have already been taken, the current situation and some prospects for the future.

**Cleaner Production 40 years in USA**

Giovanni Baiocchi

Maryland University, MD 20742, USA

**Abstract**

We will look at the progress cleaner production has made in the USA in the last forty years and the challenges for the future in the face of climate change impacts. Though considerable progress has been made, it as it has become clear that environmental gains achieved by cleaner production by reducing the environmental impact of industrial processes and the production
of goods and services, are being offset demand side trends, including rising standards of living and rebound effects. To achieve sustainable development the challenge is to establish a framework for action that goes beyond the firm to include relationships between companies, social institutions, and consumers.

**Cleaner Production 40 years in European Union**

**Gang Liu**

1 University of Southern Denmark, 29283568, Denmark

**Abstract**

Europe has played a crucial role in the initiation and further development of the concept Cleaner Production. In this talk I will give a brief introduction to the history of the theory, applications, and policy framework of cleaner production in Europe, from prevention to circular economy and sustainable production and consumption. I will use a few examples to illustrate this development and also discuss its implications on addressing overall sustainability challenges and achieving United Nations Sustainable Development Goals.

**Cleaner Production: 40 years in the Oceania**

**Linda Hancock**

1 Australian Research Council for Electromaterials Science, Deakin University, 00113B. Australia

**Abstract**

Australia and New Zealand are part of the Oceania continent, a separate tectonic plate to Asia. Oceania includes Australia and New Zealand, Melanesia, Micronesia and Polynesia; comprising 14 independent countries and 12 dependent territories that differ markedly on policies and practices central to cleaner production including: climate change NDCs [nationally determined contributions] and climate change policies across the region, CO2 emissions and continued reliance on fossil fuels, investment in renewable energy, waste, biodiversity, disaster mitigation, and marine protection. The Pacific islands in Oceania are lower in terms of wealth and GDP and are also predicted to suffer severe impacts including imminent sea level rise if global temperatures are not contained— with some predicting forced climate change migration. This paper overviews key advances and challenges in cleaner production in Oceania by focusing on “hot” issues in selected parts of the region in terms of “what have we accomplished in 40 years”.

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Cleaner Production 40 years in China

Lei Shi

‘School of Environment, Tsinghua University, Beijing, China

Abstract

The last four decades witnessed a giant step of industrial development in China. To cope with challenges brought by rapid industrialization, China stepped into sustainable transition by taking cleaner production measures, including issue of the Cleaner Production Promotion Law, pilots of provinces and cities demonstration, cleaner production audits in ten thousand of enterprises. Undoubtedly, cleaner production has contributed to the China’s economic development miracle and environmental performance improvement. This presentation intends to provide a comprehensive review of cleaner production in China. We will review the following aspects: cleaner production implementation and promotion after initial introduction of these concepts and approaches; cleaner production in key industrial sectors, such as iron & steel, pulp & paper, textile, leather, metals, cement, plastics and chemicals; history and trends of cleaner production education as part of education for sustainable development, etc. The preliminary analysis shows that: 1) the promotion and implementation of cleaner production has extended from the traditional heavy and chemical industrial sectors to the whole industrial sectors, including agriculture and service industry; 2) pollution prevention principles embodied in cleaner production have been integrated into various policies of economic development and social construction, including laws, regulations and rules; 3) a technical supporting system has been preliminarily established for cleaner production, including technical standards, evaluation index system and best available technology list; 4) the term cleaner production industry has documented in the key central government report, which means an industrial ecosystem characterized by cleaner production emerged; 5) cleaner production has permeated into all levels of education systems. On the other hand, there are still some obstacles and challenges in the in-depth implementation of cleaner production in China, including the discontinuity of policies, the movement feature of policy implementation, the poor innovation industry ecosystem, etc.
PROGRAMME
AT A GLANCE
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<thead>
<tr>
<th>Time</th>
<th>November 12th, 2019 (Tuesday)</th>
<th>November 13th, 2019 (Wednesday)</th>
<th>November 14th, 2019 (Thursday)</th>
<th>November 15th, 2019 (Friday)</th>
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</thead>
<tbody>
<tr>
<td>09:00 to 09:30</td>
<td></td>
<td>Opening Ceremony</td>
<td>Parallel Session A3</td>
<td>Special Workshop</td>
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<tr>
<td></td>
<td></td>
<td>Welcome Speech and Introduction</td>
<td>(Cleaner Production Technology)</td>
<td>Global Cleaner Production</td>
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<tr>
<td></td>
<td></td>
<td>Mayor of Sanya City (10 Minutes)</td>
<td>Chaired by Renato Santagata</td>
<td>40 years</td>
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<td></td>
<td>Chair: Zhifeng Yang (10 Minutes)</td>
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<td>Chaired by Chengyu Liu</td>
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<td>Chair: Biagio Giannetti (10 Minutes)</td>
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<td>1. Global Cleaner Production</td>
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<td>Group photo time (In the meeting room)</td>
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<td>40 years (Yutao Wang, 20 min)</td>
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<tr>
<td>09:30 to 10:15</td>
<td></td>
<td>Keynote Speech</td>
<td>Parallel Session E1</td>
<td>2. Cleaner Production 40 years</td>
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<td></td>
<td></td>
<td>Henrik Lund (Aalborg University)</td>
<td>(Green Trade)</td>
<td>in Latin America (C.M.V.B.</td>
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<td></td>
<td></td>
<td>Title: 100% Renewable Smart Energy Systems</td>
<td>Chaired by Sai Liang</td>
<td>Almeida, 20 min)</td>
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<tr>
<td></td>
<td></td>
<td>(40 Minutes, 5 minutes for Q&amp;A)</td>
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<td>3. Cleaner Production 40 years</td>
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<tr>
<td></td>
<td>Registration</td>
<td>Refreshment Break (20 min)</td>
<td>Parallel Session D3</td>
<td>in USA (Giovanni Baiocchi,</td>
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<tr>
<td>10:15 to 10:35</td>
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<td></td>
<td>(Environmental Management)</td>
<td>online, 20 min)</td>
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<td>Refreshment Break (20 min)</td>
<td>Chaired by Yanpeng Cai</td>
<td>4. Cleaner Production 40 years</td>
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<td>10:35 to 12:00</td>
<td>Renato Boero (CEO of Gruppo Iren)</td>
<td>Parallel Session A4</td>
<td>Special Session E2</td>
<td>in European Union (Gang Liu,</td>
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<tr>
<td></td>
<td></td>
<td>Title: IREN Contribution to Sustainability of</td>
<td>(Cleaner Production Technology)</td>
<td>20 min)</td>
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<td></td>
<td></td>
<td>Energy Water and Waste Management</td>
<td>Chaired by Kangning Xu</td>
<td>5. Cleaner Production 40 years</td>
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<td></td>
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<td>(40 Minutes, 5 minutes for Q&amp;A)</td>
<td>Chaired by Di He</td>
<td>in the Oceania (Linda Hancock,</td>
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<td></td>
<td>Ming Xu (University of Michigan)</td>
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<td>Parallel Session D4</td>
<td>20 min)</td>
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<td></td>
<td>Title: Life Cycle Thinking for Decision Support in Cleaner Production</td>
<td>(Environmental Management)</td>
<td>6. Cleaner Production 40 years</td>
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<td></td>
<td>(40 Minutes, 5 minutes for Q&amp;A)</td>
<td>Chaired by Xiaowen Ding</td>
<td>in China (Lei Shi, 20 min)</td>
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<tr>
<td>12:00 to 13:30</td>
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<td>Buffet Lunch and Poster Session</td>
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<td>Q&amp;A Session</td>
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<td>The Sanya Declaration</td>
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<td>(by Zhifeng Yang, Biagio</td>
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<td></td>
<td>Giannetti, and other experts)</td>
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<td>Close Ceremony (by Biagio</td>
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<td></td>
<td>Giannetti, Linda Hancock)</td>
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<td>Buffet Lunch</td>
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<tr>
<td>Time</td>
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<td>November 14th, 2019 (Thursday)</td>
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<tr>
<td>13:30 to 15:30</td>
<td>Parallel Session A1 (Cleaner Production Technology) Chaired by Weslyne Ashton</td>
<td>Parallel Session B1 (Resources Efficiency) Chaired by Lian Yu</td>
<td>Special Session F1 (Food-Energy-Water Nexus) Chaired by Ming Xu</td>
<td>Award ceremony and youth forum Youth forum Lu Ding (Tokyo Institute of Technology) Title: Clean solid biofuel production from high moisture content biomass waste by employing hydrothermal treatment technology (40 Minutes, 5 minutes for Q&amp;A) Award ceremony Sergio Ulgiati (University of Parthenope) Title: Overcoming the asymmetry between urban and rural systems Towards fair exchange and appropriate use of environmental and human capital. (40 Minutes, 5 minutes for Q&amp;A) Weslyne Ashton (Illinois Institute of Technology) Title: Building Regenerative Economies for People and Planet (40 Minutes, 5 minutes for Q&amp;A)</td>
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<tr>
<td>15:30 to 16:00</td>
<td>Registration</td>
<td>Refreshment Break</td>
<td>Refreshment Break</td>
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<tr>
<td>16:00 to 18:00</td>
<td>Parallel Session A2 (Cleaner Production Technology) Chaired by Fangqin Cheng</td>
<td>Parallel Session B2 (Resources Efficiency) Chaired by Silvio Vilgia</td>
<td>Parallel Session C1 (Carbon) Chaired by Maddalena Ripa</td>
<td>Special Session G (Water Resources) Chaired by Meirong Su</td>
</tr>
<tr>
<td>18:00 to 19:00</td>
<td>Special meeting on China-US joint project “Food-Energy-Water Nexus” (Only invited)</td>
<td>Journal Editorial Board Round Table Meeting</td>
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<tr>
<td>19:00 to 21:00</td>
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<td>Conference Dinner</td>
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</table>
PRELIMINARY PROGRAM
Tuesday, Nov. 12, 2019. 09:00–18:00 am

09:00–18:00  **Registration**

Ground Floor of Jinjiangbaohong Hotel

Wednesday, Nov. 13, 2019. 09:00–12:00 am

09:00–09:10  **Welcome Speech**

Mayor of Sanya City

09:10–09:20  **Welcome Speech**

Chair: Zhifeng Yang (Academician of Chinese Academy of Engineering)

09:20–09:30  **Welcome Speech**

Chair: Biagio Giannetti (Paulista University)

09:30  **Group photo time**

In the meeting room

09:30–10:15  **Keynote Speech I:**

Title: 100% Renewable Smart Energy Systems

Henrik Lund (Aalborg University)

Q & A

10:15–10:35  **Refreshment Break**

10:35–11:20  **Keynote Speech II:**

Title: IREN Contribution to Sustainability of Energy Water and Waste Management

Q & A

11:20–12:05  **Keynote Speech III:**

Title: Life Cycle Thinking for Decision Support in Cleaner Production

Ming Xu (University of Michigan)

Q & A

12:05–13:30  **Buffet Lunch and Poster Session**
**Wednesday, Nov. 13, 2019. 13:30–18:00 pm**

**Parallel Session A  Cleaner Production Technology**

**Chair: Weslynne Ashton**

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<th>Time</th>
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<th>Paper title</th>
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<tbody>
<tr>
<td>13:30–13:45</td>
<td>17</td>
<td>Daizhong Su, Xuemin Xu and Jose L. Casamayor</td>
<td>An Integrated Approach for Sustainable Production of LED Lighting Products</td>
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<td>13:45–14:00</td>
<td>117</td>
<td>Qi He, Han Ji and Andrew Sudmant</td>
<td>Opportunities to going green by recycling the construction waste: A case of pioneer in Beijing</td>
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<tr>
<td>14:00–14:15</td>
<td>69</td>
<td>Chu-Long Huang</td>
<td>Environmental Effect of Electric Vehicles Replacing Traditional Ones: Crisis or Opportunity</td>
</tr>
<tr>
<td>14:15–14:30</td>
<td>145</td>
<td>Jingyan Liu, Min Zheng and Kangning Xu</td>
<td>Complete recycle of ammonium, phosphate and potassium from urine into slow-release fertilizers using wood–waste biochar</td>
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<tr>
<td>14:30–14:45</td>
<td>97</td>
<td>Xiaoqing Hao</td>
<td>Features and evolution of global net fossil energy flow networks: from the exergy perspective</td>
</tr>
<tr>
<td>14:45–15:00</td>
<td>5</td>
<td>Juliana Izidoro Denise Fungaro, Felipe Campello and Sabine Guilhen</td>
<td>Column Leaching Test for the Evaluation of Immobilization of Toxic Elements in Modified Coal Fly Ash</td>
</tr>
<tr>
<td>15:00–15:15</td>
<td>175</td>
<td>Junjing Wang, Yuhao Zhu, Wei Wang, Jiawei Wang, Kuixiao Li</td>
<td>The application and evaluation of reclaimed water to urban landscape water supplement in Beijing, the capital of China</td>
</tr>
<tr>
<td>15:15–15:30</td>
<td>8</td>
<td>Carla Cristina Amodio Vinicius Sprada Maia and William Alves Maia and William Queiroz</td>
<td>Research opportunities in industry 4.0: a systematic review</td>
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**15:30-16:00 Refreshment Break**
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<tbody>
<tr>
<td>16:00–16:15</td>
<td>12</td>
<td>Paulo C. Silva and Geraldo Cardoso De Oliveira Neto</td>
<td>Cleaner production practices in textile processes an assessment focused at wastewater and effluent treatment for blue economy awareness</td>
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<td>16:15–16:30</td>
<td>14</td>
<td>Bing Wang, Ge Hong Tong Qin, Wenrong Fan and Xiao–Chen Yuan</td>
<td>Clean energy transition of coal–to–gas and coal–to–electricity in Beijing’s residential sector: command-guided or market–oriented</td>
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<tr>
<td>16:45–17:00</td>
<td>180</td>
<td>Xiaoshu Hou Shuoja Peng Liqing Guo Xu Han</td>
<td>Evaluating the stormwater quantity and quality control efficiency of low–impact development practices at multiple temporal scales</td>
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<td>17:00–17:15</td>
<td>133</td>
<td>Jinhua Li</td>
<td>Application of cleaner production in a Chinese magnesia refractory material plant</td>
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<td>17:15–17:30</td>
<td>4</td>
<td>Walter Cardoso Satyro Marcos José A. Pinto Jr. Mauro De M. Spinola,</td>
<td>Industry 4.0, Sustainability and Consumers</td>
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<td>17:30–17:45</td>
<td>148</td>
<td>José Benedito Sacomano José Celso Contador José Luiz Contador and Mauro L. Martens</td>
<td>Resource recycling and reusing the metallurgy slag</td>
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<td>17:45–18:00</td>
<td>127</td>
<td>Ben Peng Guibo Qiu Changsheng Yue Min Guo and Mei Zhang</td>
<td>Accelerating the Scale-up Towards the Circular Economy Pattern: From an Eco–industrial Park towards an Urban Agglomeration</td>
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<tr>
<td>Time</td>
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<tr>
<td>13:30–13:45</td>
<td>34</td>
<td>Oswaldo Sanchez Junior</td>
<td>Proposal of a decision support tool for retrofit in municipal street lighting services through use of the concept of eco–efficiency</td>
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<td>13:45–14:00</td>
<td>44</td>
<td>Valeria Annibaldi Federica Cucchiella Pierluigi De Berardinis Massimo Gastaldi and Marianna Rotilio</td>
<td>Building Energy retrofitting using green construction systems</td>
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<td>14:00–14:15</td>
<td>52</td>
<td>Xiaowen Ding Wei Tian, Yong Zhao and Boxin Lu</td>
<td>Improvement of instantaneous point source model for simulating radionuclide diffusion in oceans under nuclear power plant accidents</td>
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<td>14:15–14:30</td>
<td>113</td>
<td>Shangjie Li Jingjie Wang Xue Liu and Xiaoshuan Zhang</td>
<td>Evaluation System of Packaging Efficiency of Cold Chain Logistics</td>
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<td>14:30–14:45</td>
<td>109</td>
<td>Qun Li, Yalin Lei Jianping Ge Jingxue Wei and Dongrui Li</td>
<td>Geothermal Resources Development Forecast Under Policy Incentives in China: A System Dynamics Analysis</td>
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<td>14:45–15:00</td>
<td>122</td>
<td>Xiuli Liu Pibin Guo and Xiaohang Yue</td>
<td>Measuring Metabolic Efficiency of Beijing-Tianjin–Hebei Urban Agglomeration: A Slacks-Based Measures Method</td>
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<td>15:00–15:15</td>
<td>28</td>
<td>Javier Esquer Abraham Luzanilla Juana Alvarado Luis Velazquez and David Zepeda</td>
<td>Scenarios for resource use optimization in the construction and operation of a university health services building in an arid zone in Mexico</td>
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<td>15:15–15:30</td>
<td>92</td>
<td>Ying Liu and Xudong Sun</td>
<td>Natural resource demands and the structural paths of Beijing</td>
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<td>15:30–16:00</td>
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<td>Refreshment Break</td>
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<tr>
<td>Time</td>
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<td>Author(s)</td>
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<tr>
<td>16:00–16:15</td>
<td>79</td>
<td>Amos Ncube, Lynda Mangori, Rufaro Matsika, Mariana Oliveira, Sergio Ulgiati</td>
<td>Assessing potential for resource efficiency and cleaner production in Zimbabwe brick industry</td>
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<td>16:15–16:30</td>
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<td>Slawomir Raszewski</td>
<td>Achieving sustainability through efficiency: A survey of advances in and promotion of cleaner production in the oil and gas sector</td>
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<td>16:30–16:45</td>
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<td>Rute Hatsue Oji Wada, Cecília Maria Villas Bôas, De Almeida, Luiz Ghelmani Netto</td>
<td>Assessing the resource use by the ornamental plants production systems in Brazil</td>
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<td>16:45–17:00</td>
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<td>Hui Gao, Xiangyao Zhang, Qingfei Li</td>
<td>Eco-efficiency assessment and structure optimization of municipal solid waste treatment system for the typical villages and towns in the headwater of Huaihe river basin</td>
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<td>17:00–17:15</td>
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<td>Liangliang Liu, Wencong Yue, Meirong Su, Chuanwei Ji</td>
<td>Forecasting carbon emission of the industrial sectors in the Pearl River Delta Urban Cluster based on STIRPAT model</td>
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<td>17:15–17:30</td>
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<td>Xin Cao, Zongguo Wen</td>
<td>Energy conservation and emission reduction mechanism analysis of the industrial symbiosis system based on complex system simulation and MaOP algorithm</td>
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<td>17:30–17:45</td>
<td>80</td>
<td>Minyi Zhao, Ya Zhou, Yanpeng Cai, Zhifeng Yang</td>
<td>Water and carbon flows embodied in interational trade of denim</td>
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<td>17:45–18:00</td>
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<td>Yashuang Feng, Gengyuan Liu</td>
<td>A methodological review: quantitative methods of environmental pollutants on economic ecological and resource losses</td>
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## Parallel Session C  Energy–Water–Food

**Chair: Prof. Ming Xu**

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<td><strong>Osiris Canciglieni Junior</strong></td>
<td>Three product development models applied in an integrated way in the design of sustainable products</td>
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<td>Gabriela Unger Unruh</td>
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<td>Grazielle Fatima Gomes</td>
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<td>Teixeira and Roberta Ferrari de Sá</td>
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<td>13:45–14:00</td>
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<td><strong>Pengpeng Zhang</strong></td>
<td>Integrated Optimization Analysis of Urban Food-Energy-Water Nexus Based on Systematic Mathematical Modeling Approach: A Case Study of Beijing</td>
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<td></td>
<td>Lixiao Zhang and Yan Hao</td>
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<td>14:00–14:15</td>
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<td><strong>Xiaomei Shen</strong></td>
<td>Source or Sink: the Role of Biological Processes on pCO_2 Dynamics in the Pearl River Estuary, China</td>
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<td>Meirong Su</td>
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<td>Zhi Dang and Zhifeng Yang</td>
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<td>14:35–14:30</td>
<td>18</td>
<td><strong>Massimo Gastaldi</strong></td>
<td>Solar energy for public buildings: is it economically sustainable?</td>
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<td>Pasquale Marcello Falcone</td>
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<td>Idiano D’Adamo and Piergiuseppe Morone</td>
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<td>14:30–14:45</td>
<td>57</td>
<td><strong>Silvio Viglia</strong></td>
<td>Energy and water use in the U.S. catfish industry</td>
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<td>Mark Brown</td>
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<td>Jillian Fry</td>
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<td>Dave Love and Roni Neff</td>
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Chair: Feni Agostinho

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**Parallel Session B  Trade**

**Chair: Prof. Sai Liang**

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**Chair: Prof. Yanpeng Cai**

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**Parallel Session C  Carbon & Circular Economy**

**Chair: Silvio Cristiano**

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# Energy–Water–Food

**Chair:** Lixiao Zhang

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<td>Sar Sary, Xu Shiwei, Yu Wen, Nividita Varun, and Muyobozi Sikulubya</td>
<td>Household Demand Consumption Patterns in Rural Cambodia: A two-Stage ELES-AIDS Model</td>
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**Thursday, Nov. 14, 2019. 13:30–15:30 am**

# Award ceremony and Youth forum

| 13:00–13:50 | **Youth forum**  
Title: Clean solid biofuel production from high moisture content biomass waste by employing hydrothermal treatment technology  
Lu Ding (Tokyo Institute of Technology) |
|-------------|-------------------------------------------------|
| 13:50–14:40 | **Award ceremony**  
Title: Overcoming the asymmetry between urban and rural systems. Towards fair exchange and appropriate use of environmental and human capital  
Sergio Ulgiati (University of Parthenope) |
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<td>Linlin Xia</td>
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<td>Wencong Yue, Meirong Su, Yanpeng Cai, Sihao Lv, Qiangqiang Rong, Zhongqi Liu, Yanzhong Yao</td>
<td>Water resource management in consideration of ecological water requirement under changing climatic condition</td>
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<td>16:45–17:00</td>
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<td>A two-tiered attribution structural decomposition analysis to reveal drivers of CO2 emissions in the Yangtze River Economic Belt at both sub-regional and sectoral levels</td>
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<td>17:00–17:15</td>
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<td>Huaiwen Cheng and Yuwen Li</td>
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<td>Emergy synthesis of the lambari aquaculture in Brazil</td>
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**Parallel Session D  Energy – Water – Food**

**Chair: Prof. Gang Liu**

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### Special Workshop  Global Cleaner Production 40 years

Chaired by Gengyuan Liu

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| 09:00–09:20 | Yutao Wang  
Fudan University  
Editor-in-Chief of JCLP | Global Cleaner Production 40 years                |
| 09:20–09:40 | C.M.V.B. Almeida  
Paulista University  
Editor-in-Chief of JCLP | Cleaner Production 40 years in Latin America      |
| 09:40–10:00 | Giovanni Baiocchi  
Maryland University  
Associate Editor of JCLP | Cleaner Production 40 years in USA                |
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Associate Editor of RCR | Cleaner Production 40 years in European Union     |
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| 10:40–11:00 | Linda Hancock  
Deakin University | Cleaner Production 40 years in the Oceania        |
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Tsinghua University  
Associate Editor of RCR | Cleaner Production 40 years in China              |
|           | Q&A Session  
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(by Zhifeng Yang, Biagio Giannetti, and other experts)  
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SUPPORTING JOURNAL FOR THE WORKSHOP
Journal of Cleaner Production is an international, transdisciplinary journal focusing on Cleaner Production, Environmental, and Sustainability research and practice. Through our published articles, we aim at helping societies become more sustainable.

“Cleaner Production” is a concept that aims at preventing the production of waste, while increasing efficiencies in the uses of energy, water, resources, and human capital.

The Journal of Cleaner Production serves as a platform for addressing and discussing theoretical and practical cleaner production, encompassing environmental, and sustainability issues in corporations, governments, education institutions, regions, and societies.

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HOTEL PLAN
ABSTRACT
Using Emergy Accounting Method to Evaluate the Environmental Impacts in Paper Production Using Bamboo as Raw Material in Comparison to Eucalyptus

Luiz Ghelmandi Netto

Paulista University (UNIP), Brazil, Post-graduation Program on Production Engineering

Abstract

In several countries where the supply of wood raw materials is limited, bamboo is an important non-wood fiber resource used as alternative raw material to construction (Dongwe et al., 2011), reinforcing fibers (González et al., 2011, Mahdavi et al., 2012), paper production (Banavath et al., 2011, El Bassam, 1998), and other applications including nourishment (Kleinhenz and Midmore, 2001). Bamboo has also been proposed to provide bioenergy (Sculock et al., 2000; Anselmo Filho & Badr, 2004). There are also evaluations of cultures rotation, in which bamboo is used to restore soil nutrients (Embey et al. 2005; Christanty et al. 1996; Shamrughavel & Francis, 1996).

According to Souza et al. (2017), in 2015, the total pulp production capacity using alternative fibers as raw material, in Brazil, was 165 thousand tons. 77% of this amount corresponds to bamboo. The largest site of bamboo plantation in Brazil, owned by João Santos Group, is located in Maranhão state. Currently, the bamboo is the raw paper to produce kraft paper for cement sacks and boxes of milk.

Hans Kleine, a bamboo specialist, in interview to Revista O Papel (Santi, 2015) says: “For a cellulose factory to be competitive, it must produce more than 1 million of tons/year. In Brazil, we still do not have bamboo crops to attain this goal. (...) For this, the bamboo produced in Brazil will be used for other purposes, especially now, that the issue of sustainable production and supply in the area of energy has been taken up again. This means that, just as Brazil was successful in introducing pine and then eucalyptus, I am sure bamboo will have a good future”.

Corcelli et al. (2018) used the Emergy Accounting Method to evaluate the efficiency, effectiveness and sustainability of the papermaking process (office paper) under the perspectives of resource quality, fossil energy and material consumption, environmental and human-driven support. The authors assess the production of office paper using four different types of raw materials. One of them, the eucalyptus produced in Brazil.

In this work, the author aims to use the Emergy Accounting Method, to check the environmental feasibility of replacing eucalyptus by bamboo in paper production, focusing on the cultivation of raw material. For this, the data of bamboo plantation, located in northeastern Brazil, obtained in (João Santos Group, 2000) and worked in (Ghelmandi Netto, 2009; Ghelmandi Netto et al., 2012; Ghelmandi Netto, 2017), were normalized to the functional unit of 1 ton in order to compare this data with the data of paper production using Brazilian eucalyptus found in Corcelli et al. (2018).

In the preliminary results, compared with the results shown in Corcelli et al. (2018), the author could find that the amount of labor and services are more significant in the bamboo production than the eucalyptus. In other hand, the amount of energy generated by the bamboo biomass is higher than the eucalyptus.

The next step of this work is to gradually substitute the raw materials (eucalyptus to bamboo), evaluated for the Emergy Accounting Method, in order to check the environmental impact changes.

Keywords

bamboo, paper production, energy accounting method.

Industry 4.0, Sustainability and Consumers

Walter C. Satyro, Marcos José A. Pinto Jr., Mauro de M. Spinolal, José Benedito Sacomano, José Celso Contador, José Luiz Contador, Mauro L. Martins

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Postgraduate Program in Production Engineering, Paulista University (UNIP), Rua Dr. Bacelar, 1212, São Paulo, SP, 04026-000, Brazil

Postgraduate Program in Business, Paulista University (UNIP), Rua Dr. Bacelar, 1212, São Paulo, SP, 04026-000, Brazil

Postgraduate Program in Business, Campo Limpo Paulista Faculty (FACCAMP), São Paulo, SP, 13231-230, Brazil

Postgraduate Program in Production Engineering, University of July (UNINOVE), São Paulo - SP, 01504-001, Brazil

Abstract

Manufacturing represents an important sector of the economy that uses a vast range of production processes and activities. Worldwide manufacturing constitutes the second largest activity in terms of value added (Eurostat, 2018). Manufacturing underwent several transformations until the present days.

In 2011, the fourth production paradigm, Industry 4.0 was launched, made possible by digital technologies. The use of Information Technology (IT) and automation, based on the Internet, has open the possibility that humans and machines can exchange information and data, so supply chain, customers and relevant stakeholders can be integrated, interact and if necessary actuate in the production system (Cao and Yang, 2017; De Carolis et al., 2017), increasing productivity, reducing
resources, and improving quality and efficiency (Tseng et al., 2019; Romero-Gámez and Bueno-Delgado, 2018). Industry 4.0 opens the possibility of mass customization, by the flexibility introduced in the production process, so companies can produce individualized products with reduced lead-time to market (Zhong et al., 2017; Hermann et al. 2015). The aim of this study is to broaden the discussion about Industry 4.0 beyond the technical approach that has dominated the academic literature, to present some opportunities Industry 4.0 has to improve customer life in a sustainable way, and to expand the discussion that sustainability should be considered more strategic in Industry 4.0.

The research was based on literature review to find in the academic documents, studies involving Industry 4.0, sustainability and customers. The search at Scopus and Web of Science database in Jan. and Feb. 2019, presented that 64% of the total number of the documents in Scopus and 19% in Web of Science database, were technical studies that dominate the academic literature. Using Scopus database, once again, in Jan. and Feb. 2019, we initially selected 216 documents that were used in this research.

To present some opportunities Industry 4.0 has to improve customer life in a sustainable way, we highlighted the Consumer in the analyses of sustainability. It is expected that by the high level of automation, the quality of processes and products can be improved (Tseng et al., 2019; Romero-Gámez and Bueno-Delgado, 2018), reducing to a minimum the number of defective products. More efficient production processes means that water, energy and raw materials will be used in a rational scale and in an efficient way, reducing waste. By the other side, the quantity of energy to keep the companies running under the concepts of Industry 4.0 will be higher than other companies that do not have this degree of interconnection, but it is hoped that it will be compensate by a more rational use of energy in production. Circular or “closed-loop economy” can gain with Industry 4.0 technologies (Wagner, 2016). The smart products, the information provided in the QR code fixed on the products, or the sites of the companies, can provide valuable information on proper disassembly and recycling of the materials, assisting the progress of circular economy.

By the degree of importance that the circular economy gains with the scarcity of raw materials on one side and with the increase of the world population, or consumers on the other side, the sustainable development and sustainability are crucial to Industry 4.0.

With automation and IT, fewer people will be needed to work in the companies. New skills will be required; some professions will disappear, occurring functional unemployment, which happens when a person loses his job because he does not know a new technology or because he does not have the knowledge to perform a new function now required for his former job. It is important to train the team, or keep them trained; they already have the values and culture of the company, and will have lived the digital transformation of the company, potentially able to perform their new jobs in less time than new hired workers.

Companies shall focus on creating value for the consumer, and to be in closer contact with them. Consumers are each time more conscious, exchanging the experience of shopping with other consumers, facilitated by the social networks. The supply chain also should keep and enhance a more conscious and sustainable consumption standards (Wagner, 2016). To harness the full potential of interconnectivity provided by Industry 4.0, it is essential that the supply chain can adopt friendly technologies. The companies should consider developing the place where they are established, from an urban and economic perspective (Wagner, 2016), and also cultural, social and sustainable way. Companies that are concerned with local, regional or even global development tend to be respected by the consumers that see them with admiration.

Today customers demand personalized, ecological and non-expensive products, punctually at their doors (Gružauskas, Baskuris, Navickas, 2018). Customer satisfaction is fundamental factor for a successful business, so companies need to focus on the customer and follow consumer change (Bär, Herbert-Hansen, Khalid, 2018). The new technologies that make possible the digitalization of the production processes, Industry 4.0, and the smart products fruit of IoT provide new opportunities to the consumers, reducing waste and losses, in a sustainable way.

Although technical studies are dominating the research on Industry 4.0, and the significant problems with Industry 4.0, there are also opportunities to improve customer life in a sustainable way. Consumers habits are changing, they are more conscious about having more sustainable consumption patterns, so it is essential that sustainability should be considered more strategic in Industry 4.0, or these high-technological companies will not have anyone to sell their products.

Industry 4.0 brings social problems, such as unemployment perspective. Here we suggested some forms companies could have to help to overcome this negative perspective, such as provide training for team and non-team members, embracing social causes, where unemployed people could work, help local / regional / global development and others. We recognize that such an important subject should be treated in more depth, a limitation of this study, so we suggest for future research works to focus on this subject.

**Keywords**

Industry 4.0, sustainability, consumer, lifestyle, behavior

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**Column Leaching Test for the Evaluation of Immobilization of Toxic Elements in Modified Coal Fly Ash**

Juliana Izidoro 1, Denise Fungaro 1, Felipe Campello 1, Sabine Guilhen 1

1 Instituto de Pesquisas Energéticas e Nucleares, Brazil
Abstract

Fly ash is produced in huge amounts by coal combustion process for power production. In Brazil, coal ash wastes are dumped in order to minimize their disposal and monitoring costs (UFRGS, 2000), which may, somehow, not avoid contamination on sites where they are deposited. In addition, storage of coal ashes in sedimentation ponds occupies large land areas, which could be used for other purposes, such as agriculture. Moreover, this type of disposal can generate various and serious environmental problems in the future.

Therefore, studies of leaching and stabilization of coal combustion by-products are necessary in order to avoid the contamination in soil, surface water, groundwater and, vegetation. It is well-known that this residue has high levels of trace dangerous elements such as As, Cr, Mo, Ni, Se, and others (Bhattacharyya, 2010; Depoi et al., 2008). Those elements tend to concentrate mainly on the fly ashes in smaller particle size (Izidoro et al., 2017). Some immobilizing agents have been used to prevent the leaching of the toxic elements in coal ash, for example, surfactants, iron sulfate and iron chloride III (Meng et al., 2000; Daniels et al., 2009; Bhattacharyya, 2010). In addition, Daniels et al. (2009b) reported that inorganic compounds, organic substrates (such as synthetic polymers), biochemical compounds (as biofilms) can also be used to immobilize trace elements from ashes.

Recent studies have shown that silicon-containing organic compounds (organosilanes) can be mixed with coal ash to form a nanocomposite with a hydrophobic surface, which can reduce the hydraulic conductivity of the ash and thus, alleviate the leaching capacity of toxic elements (Daniels et al., 2009; Daniels et al., 2009b).

Surfactants, similarly, can also modify the surface of the ashes, making it as a hydrophobic material to prevent the contact of its surface with the aqueous medium (Banerjee et al., 2006; Banerjee et al., 2006b).

The aim of the present work was to study the immobilization of the main toxic elements presented in coal fly ash by treatment ashes with immobilizing agents to reduce the possibility of environmental impacts of coal ash disposal. Laboratory leaching tests as column percolation tests were performed using fly ash modified with organosilane (OS) and quaternary ammonium surfactant (SF). A sample of coal fly ash from baghouse filter was collected at the Figueira coal-fired power plant located in Paraná State, Brazil. The quaternary ammonium salt, hexadecyltrimethylammonium bromide (HDTMABr, CH₃(CH₂)₃N+(CH₃)₃Br⁻, M.W. = 364.45 g mol⁻¹) and organosilane ethoxytrimethylsilane (ETMS, (CH₃)₃OSi; M.W. = 118.25 g mol⁻¹) were used for ash modification. Tests were carried out in triplicates with columns containing coal ash and soil collected in the Figueira Thermoelectric Power Plant region. The columns were filled with an upper and bottom layer of soil and a central layer of fly ash (untreated fly ash, OS treated fly ash or SF treated fly ash). The columns were percolated with synthetic acid rain simulating the precipitation that occurs in the region. Once per week, the percolate was added to the top of the columns and the leachate sample from each column was collected and subjected to argon plasma optical emission spectrometry (ICP-OES - Spectro, Model Arcs) for the determination of the elements Cr, Mo, As and Se. The total test duration was 4 weeks.

In the column with OS treated fly ash there was a considerable reduction in the concentration of As (67 %) and especially of Cr (70% ) in the leachate. After treatment with SF treated fly ash, concentrations of As and Cr of the leachates reduced approximately 30%. In both treatments, the concentrations of Mo and Se were also significantly reduced. The concentrations of all elements were lower than the concentrations in the leachate of the untreated ash tests. The results showed that both the organosilane and the surfactant can be used as immobilizers for the retention of toxic elements present in coal ash.

Keywords

c coal fly ash, immobilizing agents, organosilane , surfactant , column percolation leachings

Reflection about the interrelation among the functions definition stage and the solutions definition stage in the integrated product development process (IPDP)

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Abstract

The search for competitive differentials in current industry has required conceptual changes in new product development processes. In this way, evaluating the product functions and associating them with its manufacturability aspects has been crucial for cost reduction and for obtaining a better balanced of the design regarding the value perceived by the customer and the real manufacturing costs to meet each of the functions. However, there are not relevant studies showing the current state of the art for methods that cyclically interact with the phases of an integrated product development process (IPDP) assessing the issues of product functions, perceived value by the consumer, solutions definition and manufacturing costs. The objective of this study is to seek the frontier of knowledge regarding methods and researches that specifically encompass the design phases that define the functions and phases that define the solutions of a new product in an engineering environment simultaneously. For this, a systematic analysis of the literature was proposed, in order to list the main
journals, articles and authors that discuss and produce knowledge about this topic. For this, a rigorous methodology was carried out in different databases, covering articles published in scientific journals in the last 10 years. The structure of the research consisted of four steps: search, analysis and selection of recent research; categorization of selected articles; citation frequency analysis, where the selected articles were analyzed, and the identification of main research references. Among the results, this study presents a report showing the relevance of the information collected, its particularities, impacts and limitations.

**Keywords**
Design for assembly, Value engineering, Integrated product development process, Systematic literature review

**Requirements and barriers in the food exportation from Brazil to Europe: an exploratory study**
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**Abstract**
Export is one of the best ways for a company to leverage its growth and the food industry is one of the sectors that stands out most. However, only the large companies have a good support and knowledge of all procedures involved. The small companies face difficulties due to the high cost and the lack of mastery of the procedures demanded. This happens especially when they face the countries of the European Union, that are highly exigent, but which are the potential buyers; they demand many requirements for importation, including sustainability issues. Therefore, this work aims to explicit the most of requirements and barriers involved in the food export process from Brazil to Europe. For this, a bibliographic review is presented on the internationalization of companies, requirements and difficulties in this export process. Aiming to verify if the difficulties found in the literature are compatible with those of the industries, four small companies that exported in 2016, located in the Paraná State (Brazil), were invited to participate in a survey to explain the difficulties found in this process. In addition, professionals from the area were also interviewed, such as the Manager of the International Innovation Centre of FIEP-PR (Federation of Industries of the Paraná State), the Business Analyst of the International Business Centre, the Representative of the Commercial Area of a food industry of medium-sized, the Customs Brokers, and the International Export Consultant - Foreign Trade. Finally, the export process of a small food industry that was initiating an export to Europe was accompanied, in order to identify all the requirements and procedures demanded in this process. This work shows the main requirements and barriers involved in the food export process from Brazil to Europe, aiming to support the small enterprises.

**Keywords**
Food industry, exportation requirements, exportation barriers, internationalization, Brazil-Europe

**Research opportunities in industry 4.0: a systematic review**
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**Abstract**
Industry 4.0, called the fourth industrial revolution, focuses on the computerization of processes, creating an independent and intelligent company. Independence refers to its self-management through immersive technologies and artificial intelligence. Therefore, it is characterized by the integration of intelligent manufacturing into the means of production, understood by a variety of technologies such as Internet of Things, Cyber-Security, Additive Manufacturing, Augmented Reality, Systems Integration, and others. Due to its importance in the industrial environment, which seeks to maintain its competitiveness, following the trends of the market, this theme has gained prominence in the academic and industrial circles in recent years. An increasing number of publications on the subject begins to emerge in 2016 and is therefore a recent topic, which is still demanding investigations. Therefore, the aim of this work is to identify the research opportunities in this topic, aiming to direct future research. For this, it presents a systematic literature review, identifying the main means of publication. Keywords are identified and submitted to databases of scientific relevance, such as: Web of Science, Science Direct, and Scopus. The first selection is limited to articles written in English, peer-reviewed in the engineering area, and published until 2019. Next, a selection of the original journals is made, considering only those with an impact factor (Journal Citation Reports (JCR)) higher than 2.4. Then, the titles and abstracts are read, in order to select the ones of greater relevance to the intended goal. Some exclusion criteria were also considered, in order to maintain the focus of the study. After this quantitative and qualitative selection, all the papers selected were analyzed. Among the results, the study presents the characterization of research on the topic and its frequency of publication, ending with the main research opportunities.
on the industry 4.0, including new topics or subjects in development.

Keywords
Industry 4.0, Internet of things, research opportunities, systematic literature review

Cleaner Production practices at wastewater treatment as agent of Blue Economy

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Abstract
The Blue Economy, as a sustainable development strategy, has gained acceptance and importance worldwide (Mulazzani and Malorgio, 2017). There is a global effort to develop technologies and disseminate initiatives to a sustainable blue revolution in aquatic systems (Bosma and Verdeger, 2011). It gains notoriety by the estimation that roughly 40% of the world’s population, about 2.8 billion, live within 100km from the coast (Liu et al., 2018). Thus, the main concern is the marine ecosystem conservation and to find solutions for the world’s major issues such as security of food, water supply and energy (Dalton et al., 2019). Moreover, the Blue Economy addresses topics such as the excessive freshwater consumption, organic pollution and chemical contamination (Bosma and Verdeger, 2011). In this context, as highlighted by Graziano et al (2019), there is a connection between the coastal environmental and industries outside of their proximity, due to the impact of its operations on water-based activities. Marine pollution are also from land-based sources such as agriculture, mining and manufacturing (IOC/UNESCO et al, 2011). Studies on the land-ocean interaction took into account the industrial activity as an agent of changes in water quality of rivers draining into the Atlantic Ocean (Zabrey et al., 2017) and the North Sea (Neal et al., 1997).

Indeed, the water crisis tackled by cities reflects the negligence of this topic by the earlier generations. The challenge for authorities and managers consists at ensuring the availability of drinking water for human consumption. In this sense, there are several projects on the land-ocean interaction deals with catchment based hydrological and freshwater resource issues (Ramesh et al., 2015). Hence, industrial manufacturers are required to adopt technologies for water conservation and pollution control (Chen et al., 2017). However, business is economic-oriented then projects aiming the environmental preservation have to offer economic advantages. In this line, the implementation of Cleaner Production initiatives have delivered environmental benefits associated to cost saving (Oliveira Neto et al., 2016). There are applications of Cleaner Production practices for water conservation in orange canning production (Wu et al., 2016), small firms in Mexico (Hoof et al., 2013), porcelain tile powders (Shu et al., 2012), pulp and paper industry (Zarkovic et al., 2011), pet food factory (Uttamangkabovorn et al., 2005) and crsytal glass industry (Lee et al., 1997). In addition, the water reuse at industrial applications is an alternative for reducing the input of freshwater in operations and the impact on the aquatic ecosystem (Skouteris et al., 2018). The advantages of water reuse through wastewater treatment were noted in fish canning industry (Cristóvão et al., 2015), textile sector (Amar et al., 2009) and food processing factories (Hafez et al., 2007).

This study shows the benefits reached by improvements of industrial effluent in a cosmetics factory. The wastewater composition of cosmetic products carries on high Chemical Oxygen Demand and concentrations of organic compounds with low biodegradability (Melo et al., 2018). The reduction of pollutants in industrial effluent allowed the water reuse by the company, which decreased the input of freshwater in process. The environmental assessment was conducted by the Mass Intensity Factor methodology, which calculates the impacts on water, air, biotic and abiotic compartments (Oliveira Neto et al., 2017). This approach met the findings of Mulazzani and Malorgio (2017) that embedded the ecosystem services, including abiotic compartment, in the accounting of Blue Economy. By the economic side, Return on Investment was the method to calculate the economic feasibility based on operational costs and required investments. Besides the tangible gains, there are advantages in terms of corporate image and compliance with environmental legislation.

The results pointed out advantages at decreasing the wastewater contamination and freshwater consumption. These findings denoted the impact of industrial activity on aquatic system, as consequence, for the Blue Growth. The synergy between authorities by establishing strict regulations and companies through the Cleaner Production mindset is basis to preserve the natural resources and human health. This finding denoted that Cleaner Production is a mean to promote sustainable development at the Blue and Green Economies. The improvements at the wastewater treatment resulted in cost savings by reducing the energy and water consumptions, total of USD 1,798.00 per year. By the environmental view, the use of Mass Intensity Factor (MIF) methodology increased the accuracy of environmental impact, compared to the mass balance calculation. The reduction of environmental impact accounted through MIF was 66,666,086.69 kg of material, whereas the mass balance pointed out 48,523,415.46 kg.

The application of MIF methodology is even more essential for investigations under the Blue Growth perspective, due to the fact that damages on aquatic system are frequently blind to human perception. Thus, quantitative studies should adopt this approach to ensure a complete environmental impact analysis, taking into account all natural compartments, abiotic, biotic, water and air. Finally, this study makes significant contribution to increase the knowledge on Blue Economy and its application in the corporate practice.

Keywords
Blue Economy, Cleaner Production, wastewater treatment, water reuse, cosmetics industry, Mass Intensity Factor
Disorganization of the reverse logistics and recycling of textile waste delay advances in the Brazilian circular economy

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Abstract

Reverse logistics is a challenge to be faced by the textile sector, with activities that can foster a circular economy, such as recycling and reuse of materials. Industrial waste represents difficulties in all countries and coping is necessary. In Brazil it is no different, in 2010 a National Solid Waste Policy (PNRS) was implemented and after almost a decade the textile industry is still far from being adequate to regulation. The consumer society and its unstoppable garbage production need action to reverse this situation. Education and conscious consumption are urgent, especially in developing and poorer countries. The objective of this article is to evaluate the scenario of the initiatives of recycling and reverse logistics carried out in the textile and clothing industry in Brazil from the point of view of legislation and is presented through bibliographic research in national and international databases, social networks, internet sites and open data analysis of national and international bodies on the subject. It is concluded that the governmental incentive through legislation is fundamental for the country to make a qualitative leap and start implementing reverse logistics in the textile chain in a consistent manner, which has not yet occurred.

Keywords

import of garbage, legislation, reuse of wastes, textile wastes

Blue Economy and Cleaner Production practices: a study case at wastewater treatment in field of aeronautical maintenance

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Abstract

The Earth is a blue planet, with 71% of surface covered by water, but nearly two-thirds of the world’s largest rivers are clogged by dams and other infrastructure, resulting in impacts on the environment and the communities that depend on these rivers, and an increasing number of cities that depend on rivers and oceans without being able to mitigate environmental impacts they are generating, it is no longer possible to look at rivers and oceans and consider them only as waterways or means for energy production (Golden et al., 2017; Grill et al., 2019). In this sense and in line with more widespread concept of green economy, the concept of Blue Economy has been deployed, with the objective of balancing the sustaining economic development opportunities with maintaining aquatic systems health (Keen et al., 2018).

Furthermore, pollution of the aquatic environment has grown more serious recently, there are some examples as case study that presented how large are this problem, that is the scenario of Chinese Yangtze River, where the areas along the river are densely populated and have highly developed cities, therefore, the river is polluted by sewage, inadequate discards, among others (Zhang, 2014).

In the rivers and oceans, humans are now carrying out all of the activities that traditionally were associated with terrestrial industrial processes. This means that whereas the last years was characterized by efforts to make terrestrial development more sustainable, these actions are likely to give rise to governmental policies that address the sustainable industrialization of the rivers and oceans (Kathijores, 2013). There are a lot of products from the aquatic system that compound this industry, but it is unanimous that freshwater is the most important and one of the product that has increased the most consumption in recent years.

However it is important to note that the term blue economy are relatively new and despite their increasing use in the literature, it is not completely defined. Additionally, it seems clear that sustainability has a strong relation with this concept (Mulazzani and Malorgio, 2017).

But there is a precariousness of discourse in global environmental governance, one way to show this is that most countries do not have specific laws to follow and even when there is one, it is very hard to comprehend. Moreover, even so when these laws are fulfilled, there is no corresponding authority to carry out to check the correct application. Therefore, should step up efforts in the study of relevant standards of compensation and link through law enforcement (Zhang, 2014; Silver et al., 2015).

Thus, application of Blue Economy concepts aiming environmental preservation has a higher success rate when the project is economic-oriented, per example, considering an environmental and economic evaluation of the results. In the light of literature, the adoption of Cleaner Production practices allows the inclusion and enhancement of environmental care and reducing the environmental impact, all of this aligned with cost saving (Oliveira Neto et al., 2016). There are applications of Cleaner Production practices for urban water management in India (Adapa, 2018) and in Zimbabwe (Nhapi and Hoko, 2004), there are cases of reduction of water consumption in productive processes of the metal-mechanical industries (Severo et al., 2015), in metal finishing facilities, that uses large quantities of harmful chemicals and water, making it a highly polluting sector (Laforest et al., 2015), in a medium size gold-plated jewelry company, a kind of industry that uses harmful
chemicals and water too, and more complicated to be applied for not being a large company (Giannetti et al., 2008), in a sewage treatment system (Zhang et al., 2015) and in a water purifier production process (Sousa-Zomer et al., 2017). All these cases are related to the economy and rational use of water, as raw material, input, chemical treatment or final product.

This study shows the benefits reached by improvements of industrial effluent in aircraft maintenance hangar. The wastewater composition of aeronautical repairs processes has high inorganic and organic species levels, including acids, caustics, salts, oil, detergents, heavy metals, chromates and cyanides (Slater et al., 1981). The reduction of pollutants in industrial effluent allowed the water reuse by the company, which decreased the input of freshwater in process. The environmental assessment was conducted by the Mass Intensity Factor methodology, which calculates the impacts on water, air, biotic and abiotic compartments. The economic assessment was obtained by the method of the Return on Investment based on operational costs and required investments (Oliveira Neto et al., 2017).

The results presented advantages at decreasing the wastewater contamination and freshwater consumption. These findings demonstrated the impact of industrial activity on aquatic system, as consequence, for the Blue Economy. The implementation of Clean Production practices and use of Mass Intensity Factor methodology improve the analysis of environmental impact, compared to the mass balance calculation. The water reuse in the wastewater treatment allowed calculating a return on investment of 1 year and 11 months for the company; in addition, 995 ton of environmental impact was avoided. Furthermore, the application of this methodology helps to make the damages on aquatic system more evident, thus well aligned with Blue Economy perspective. It is a recommendation that future studies adopt this approach to ensure a complete environmental impact analysis. About this study makes significant contribution to increase the knowledge on Blue Economy and its application in the corporate practice.

**Keywords**

Blue Economy, Cleaner Production, wastewater treatment, water reuse, aeronautical maintenance, Mass Intensity Factor

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**Cleaner production practices in textile processes an assessment focused at wastewater and effluent treatment for blue economy awareness**

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**Abstract**

After the Rio + 20 meetings in which the result according, Ababouch et al. (2015) proved to be a strong incentive in promoting new efforts for the implementation of previous and new commitments in oceans and inland waters to restore, exploit and conserve resource waterways. There was broad consensus that Blue Economy may meet the requirements for such an approach, Ababouch et al. (2015); Van Wyk, Jr-Annie (2015), as discussed in various conference and adopted by the OECD.

UNEP and FAO also presented studies that showed how the blue economy can cover the various economic sectors that use the oceans and inland waters such as coastal fishing, inland fisheries, aquaculture, tourism, renewable energy, finish textile industry, mining and biotechnology.

For Pauli, G.A (2010) the innovations identified through long-term research known as "The Blue Economy," inspired by the Blue Planet of the Earth with a blue sky and a blue ocean, are becoming a great platform to stimulate entrepreneurs, changing the economy in a vertical way from a base to the top. This allows to take thousands of technologies to the market, to work in different conditions, to improve the know how in the use of these in the most different applications. Is to do more with the resources available, using comparative innovations to stimulate entrepreneurs to become market leaders (Pauli, G.A. 2010).

A vast amount of research addressing issues of blue economy has been directed to the economic sectors of sea and inland fisheries as well some other industries related to dependencies of water resources as main element in its process, such as agriculture, textile, food. Fish production needs to be increased by implementing an ecosystem approach to fisheries or aquaculture in order to protect environmental areas by reducing pollution levels and also restoring the environment involved (Sarker, Subrata, et al. 2018). In fact, Pauli, GA (2010), states that Blue Economy applies to any business sector, and to increase the availability of not only gains in the local economy, and the use of locally available resources, is dedicated to eliminating what does not it is necessary.

Sustainable approaches address the needs of the present without compromising the ability of future generations to meet their own needs. For Kaczynski, Wlodzimierz 2011 the Blue Economy industry is emerging now, just as space exploration has developed since the 1960s. Uncontrolled growth of numerous and varied pollutants in all ecosystems resulting from men’s actions from local to regional and globalization. Bogdan et al. (2014) actors involved and an important part of responsible civil society struggle vigorously and with plausible arguments for the sustainable development of humanity through green economy and performance as well as clean technologies. Added to the concept of blue economy proposed by Gunter Pauli, a concept that is based on the application of the mechanisms and principles of nature for the development of humanity.

Nature responds to basic needs and then evolves from sufficiency to abundance, while the current green model, according to Nicholas G., Roegen (2014), is based on scarcity as the basis for production and consumption. Twomey et al. (2016) evaluated in his research that the blue economy partly fits in opposition to the standard paradigm of the green economy,
from the observation of Jewell (2014) where the green economy is perceived as a linear, gradual, incremental process of return decreasing, where the end point is simply to do something unsatisfactory. Some countries in Asia have implemented a series of cleaner production initiatives, Oliveira Neto et al. (2019) cites Turkey as the country with the highest number of researches related to the implementation of cleaner production (CP) practices in the textile industry.

In an analytical way the present research through a case study on the implementation of cleaner production practices in a line of textile processing with its respective impacts in the treatment of textile effluent and later reuse water of this wastewater in the fluvial courses to meet the necessity and availability of this by the community in agriculture, livestock, construction, among others. Concomitantly aimed at alloying green strategies and their clean technologies to the concepts and concerns of blue economy principles for sustainable goals.

The results showed that maintenance and follow-up of the cleaner production practices implemented in industrial processes contributed to the economic and environmental gains evidenced by improvements in wastewater treatment that resulted in cost reduction, reduction of energy consumption, water consumption and reuse of raw materials. In agreement with the principles of the blue economy from the obtained environmental advantages, it can be verified a greater availability of treated water and appropriate for the use of the community.

For the environmental evaluation, the “Mass Intensity Factor” coefficient tool of the Wuppertal Institute was used to measure the environmental impact associated with the extraction of resources from its ecosystems. This allowed quantification of the material intensity in the compartments classified as Abiotic, biotic, water, air and erosion, according to the method developed by (Oliveira Neto, 2011). The raw material yield obtained throughout the process represented a reduction of solid waste disposal in the environment of 5,175 kg, called total material saved (MTS), which added to the energy reduction of 253,859 kWh / month, generated a total mass intensity (MIT) in the sum of the compartments of 689,845 ton / month. And a reuse of 18.6% of wastewater, such as 15% reduction in toxicity, heavy materials and sludge load in treated water for community use. As a result, this research shows us the possibility of combining the clean technologies of the concepts of green economy aligned with the principles of the blue economy.

Keywords
Cleaner production practices, wastewater, effluent treatment, textiles processes, Mass Intensity Factor

Air pollution losses and its correlating influences: based on China’s provincial analysis
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Abstract
Air pollution is not only a simple resource and environmental pollution problem, it has a huge negative impact on human health and ecosystems which has evolved into a major economic and social problem. Therefore, quantifying the loss of human air pollution and ecosystems of China’s provincial air pollution is of great economic and social significance.

At present, researches on the impact of air pollution on human health is concentrated in two aspects. The first is to use the exposure-response model and the poisson regression model to study the physical effects of air pollution on human health, including the effects on respiratory diseases (Guaita, Pichule et al. 2011) and heart diseases (Li, Zeng et al. 2016). The second is to use the cost of illness, willingness to pay and the human capital approach to study the health economic loss of air pollution. This paper selects Disability Adjusted Life Years (DALYs) to account for human capital losses, making up for the shortcomings of the above methods for underestimating the value of life. In addition, there are few studies on the loss of natural capital. Ugliani & Brown (2002) calculated the additional energy value of the environmental services needed to dilute emissions. Wang et al (2019) applied the energy theory to calculate the ecological service value of the Yangtze River Delta region. Energy analysis can unify the economic system and the social ecosystem, and is the bridge between ecology and economics. However, the current studies mostly focus on areas or major cities or a single pollutant studies (Lu, Lin et al. 2017; Sun, Fang et al. 2018), and few studies to quantify the loss of different pollutants in the national provinces. Therefore, we select the annual emissions of five air pollutants of SO2, NO2, CO, PM10 and PM2.5 emitted by the four departments of power, industry, civil and transportation in China’s 31 provincial-level administrative regions in 2008 and 2010, and it can be more accurate and more comprehensive to quantify the air pollution loss based on the energy value theory and Eco-Indicator 99. Our work is mainly divided into three parts. First, we use the energy value theory and the Eco-indicator 99 to quantify China’s provincial air pollution losses, including ecological services, human capital losses and natural capital losses. Second, we use the Moran’s I to study the correlation and agglomeration characteristics of China’s provincial air pollution emissions and their losses. Finally, we consider spatial dependence based on spatial regression methods to study the influencing factors of air pollution.

We have the following findings through our research. Firstly, the overall loss of air pollution in China’s provinces is relatively serious, and it presents a pattern of “high east and low west”. Taking 2010 as an example, the sum of human capital losses and natural capital losses in eastern provinces such as Shandong, Henan, and Hebei has respectively reached 8.92E+2560, 5.53E+2352 and 5.28E+2352, while the losses in Tibet and Qinghai of western provinces are 5.75E+2154 and 3.52E+2156. There is still a big difference between them. Secondly, the key provinces, core pollutants, and key sectors are different in
terms of air pollutant emissions, ecological services required to dilute air pollution, human capital losses and natural capital losses due to air pollution. Among the five pollutants, although CO emissions accounted for the highest proportion, the human capital loss caused by it was far less than PM_{2.5} and PM_{10}, which accounted for less emissions; the largest contribution to natural capital loss was NOx. The impact of industrial and civil sectors on air pollutant emissions, ecological services, and human capital losses is relatively obvious. For natural capital, the power, industry, and transportation sectors are the main contributors. Furthermore, spatial autocorrelation analysis verified the existence of significant regional differences and agglomeration effects of air pollutant emissions, human capital losses and natural capital losses. At last, global regression model analysis shows that the total population of the province and the industrial structure have a significant positive impact on air pollutant emissions. These results help individual provinces to effectively control and control against governance and are of great significance for collaborative governance across multiple provinces.

**Keywords**

Natural capital loss; Human capital loss; Energy value; Moran’s I

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**Clean energy transition of coal-to-gas and coal-to-electricity in Beijing’s residential sector: command-guided or market-oriented**

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**Abstract**

Heavy smog hovers over the Chinese sky and decisions were made to carry out intensive action plans to reduce air pollution, especially in the Beijing-Tianjin-Hebei region and neighboring areas and the Yangtze River Delta region. During these plans, coal-to-clean energy measures become the principle action for air quality improvement in the residential sector. As one of the most smog-affected cities, Beijing is the pioneer to “declare war” on smog prevention since 2013 and has made great progress in improving its air quality in recent years by reducing major airborne pollutants and achieving its national air quality goals.

This paper was designed to investigate the current situation of coal-to-clean energy plan implementation and public satisfaction about this smog prevention action. A multi-agent impact factor model is built to figure out the proper framework for enacting this residential clean energy consumption plan and to examine the conditional support for the coal-to-clean energy campaign. With a combination of online questionnaire investigation and onsite field survey, the factors governing the work efficiency of this energy transition engineering program was also explored. Results found that public choices are sensitive to the subsidies around the coal-to-clean energy. The passive role of residents in receiving the clean fuels services suggests that the current clean energy transition in Beijing’s residential sector is command-guided rather than market-oriented. Most affordable communities have the willing to take efforts for blue skies. The knowledge provided by this paper may contribute to motivate the project stakeholders to be engaged in residential clean energy transition especially from the public participation perspective.

**Keywords**

Prevention and control; Coal-to-gas; Coal-to-electricity; Energy transition; Beijing

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**Carbon Trading Mechanism Based on Generalized Nash Equilibrium Model**

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**Abstract**

Establishing a fair and effective initial carbon quota allocation scheme is the cornerstone of China’s unified carbon market. Starting from equity and efficiency, considering the market characteristics and healthy and stable operation of subsequent carbon trading, this paper establishes a generalized Nash equilibrium model for abstract emission entities, markets and governments, and studies the conditions for achieving a balanced and stable distribution. For the government, under the condition of ensuring that the distribution amount of each emitter is lower than the original emission amount, this paper improves the quality of distribution, aiming at minimizing the residual emission rights of the emitter, and completes the initial distribution of the emission rights of each emitter. For the emission subject, the maximum production benefit of each emission subject under the specific technology level is the goal, and the impact on production is minimized. The residual amount of the emission right is determined by the emission
subject. For the characteristics of carbon trading market, in order to ensure stable and healthy operation, the objective is to minimize the difference between demand and supply of carbon emission rights among different emitters, and to seek a reasonable carbon trading price. Finally, the equilibrium conditions of the generalized Nash equilibrium model composed of the above models are analyzed.

**Keywords**
initial allocation of carbon quotas carbon emissions trading carbon trading price generalized Nash equilibrium model

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**Effects of residential and industrial disposal containing mercurial lamps in fruits, in developing countries**


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**Abstract**

One of the significant challenges of the production system is the reduction of emissions of materials containing toxic waste to human health and biota. Developing countries still use mercury lamps in their industrial plants, constituting a source of contamination by trace metals in the environment, due to inadequate final disposal, with potential for transfer to other environmental compartments, such as soil, water and vegetation. This fact can lead to possible environmental contamination and negative impacts on the health of the population.

Trace elements can be from inorganic or metallic sources; if they are trace metals, there is the possibility of being considered toxic. Their origin may be due to misuse of land, mineral exploration and waste disposal (DEMIREEZEN; AKSOY, 2006).

Metals in small quantities (trace metals), derived from metal oxide vapours, contained in industrial and urban waste, can contaminate the soil and vegetation with zinc, cadmium, copper and lead (BUCHAR, 1973).

Variable composition of the soil and pH alteration can result in different absorption of trace metals in plants, resulting in significant quantitative of trace metals in the roots and fruits (LÜBBEN; SAUERBECK, 1999; KABATA-PENDIAS; PENDIAS, 2001).

Fruits are essential foods for mammals, birds and insects. They contain vitamins, minerals, fibres and have antioxidant effects. So the determination of trace metals in diet is vital for the quantification of the level of contamination in humans and the various living beings that feed on them (BASHA et al., 2014; ELBAGERMI, M. A.; EDWARDS, H. G. M.; ALAJTAL, A. I., 2012; SHAHEEN et al., 2016).

The primary source of non-occupational human exposure, for most trace metals, is through food intake, and its effects on humans depend on the ingested trace metal. In general, the results are related to neurological changes, some types of cancer, chromosomal damage that can affect many organs, including the gastrointestinal, cardiovascular, nervous and hematopoietic systems (ICPS INCHEM, 2010).

The present study evaluated the concentrations of trace metals in mango fruit, obtained from the hedges of the School of Civil and Environmental Engineering (EECA) of the Federal University of Goiás (UFG), Center-West Region of Brazil. Slice samples were collected in three different locations, where there was incorrect disposal of waste containing mercury lamps. For the quantification of these metals, the analytical method ICP-OES was applied, and the samples were digested in a microwave digester, with taken readings by the axial configuration.

The metals: Al, As, Co, Hg, Mo, Pb, Sb, Se, S, Tc and Tl, were below the limit of quantification, making their analysis unfeasible because they were below the limits of precision and accuracy acceptable under the experimental conditions established (BRAZIL, 2017).

Several trace metals are not found in the FAO/WHO standards: B, Ba, Be, Bi, Ca, Co, Cr, K, Li, Mg, Mn, Mo, Na, Ni, P, Sb, Se, Sr, Te, Tl and V, making the discussion on contaminants and toxins in food inconclusive, because it is not possible to evaluate whether these trace metals, when ingested in quantities above those predicted, can cause effects on human health.

The trace metals Cd, Cu, Fe, and Zn, found in the analyzed samples were above the limits in FAO/WHO standards. The decreasing order of average levels obtained for mango fruit samples was: Fe > Zn > Cu > Cd.

The effects on exposure to cadmium (Cd) in humans can promote inhibition of the functions of metallothionein, developing weakness, obstructive lung disease, thickening of the arteries, hypertension and in case of occupational exposure can result in lung and prostatic carcinomas (PASCALICCHIO, 2002).

Excess copper (Cu) causes epigastric pain, headache, nausea, dizziness, vomiting, diarrhoea, tachycardia, difficulty breathing, hemorrhagic anaemia, hematuria, massive gastrointestinal bleeding, liver failure and renal failure (IPCS INCHEM, 1998).

Single or short-term exposure to zinc (Zn) concentrations causes symptoms of gastrointestinal discomfort, nausea and diarrhoea. Inadequate intake causes sensorineural changes, oligospermia, impaired neuropsychological functions, growth
retardation, wound healing changes, immune disorders and dermatitis (IPCS INCHEM, 2001).

Excessive iron (Fe) intake is associated with fibrosis and cirrhosis of the liver, deposition of iron in the pancreas, suprarenal, thyroid, pituitary and heart (IPCS INCHEM, 1983).

The incorrect disposal of electrical and electronic waste from household and industrial waste has direct harmful effects on human health and biota, through the ingestion of foods essential for the nutrition of living beings who feed on these types of foods, in addition to the diffuse contamination of the environment.

Keywords
electronic waste, pollution, trace metals, human health, cleaner production

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An Integrated Approach for Sustainable Production of LED Lighting Products

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Abstract

Lighting products are essential in our lives, but they also produce a high environmental impact. There are tools and methods available for reducing the environmental impact at different stages of the lighting product production; however, it is a challenge to integrate them in order to achieve sustainable production. To overcome the challenge, this research developed an approach to integrate relevant eco-production tools/methods into the lighting product production process.

The eco-production methods considered in this approach include: (1) Elaboration of product design specifications with eco-constraints, such as reduction of product carbon footprints, energy/material consumption, waste, and contribution to climate change, etc. (2) Product lifecycle impact assessment methods, such as, Recipe, EI-99, material footprints, etc. (3) Product failure analyses, such as failure mode, effect and criticality analyses, etc. (4) Eco-design methods, such as modular design, design for re-use, design for recycling, etc. (5) Eco-manufacture, eco-packaging, etc.

The categories of eco-production tools considered in this approach include: (1) Regulations, directives, voluntary and legislations, for example, directive 2012/19/EU ‘Waste electrical and electronic equipment (WEEE)’. Currently 15 tools are considered in this category. (2) Standards, for example, standard ‘UL 8750-2003: Light Emitting Diode (LED) Equipment for Use in Lighting Products’. This category currently includes 15 tools. (3) Software-based tools are used for selection of LED chips and lifecycle assessment software packages, such as SimaPro. Currently 7 such tools are considered. (4) Light analysis/measurement tools are used to validate/confirm the efficient light performance (light quantity/quality and power consumption) of the LED lighting product, for example, goniophotometer. Currently 9 such tools are considered.

Keywords
Sustainable production, lighting products, LED, eco-design, eco-production, product design

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Solar energy for public buildings: is it economically sustainable?

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Abstract

Solar photovoltaic (PV) is becoming a leading power generation capacity and over 100 GW of new PV power capacity has been installed in 2018 reaching a cumulative value in excess of 500 GW at the end of 2018. About one-third of global installed PV capacity is located in China (about 80 GW), followed by the European Union (EU), in particular Germany, Italy and United Kingdom, with about 127 GW, United States with about 65 GW, Japan with about 56 GW and India with about 37 GW show a significant value of power installed (Jäger-Waldau, 2019).

The broader literature perspective of solar PV system recognizes that the societal costs for the carbon emissions are mostly paid, directly or indirectly, by the citizens. Mandatory carbon emissions liability must be defined within the constitution al perspective (Choudhary and Srivastava, 2009). The price of carbon dioxide is increased with respect the previous years (about 4 €/tCO2eq) and it ranges from 15 to 25 €/tCO2eq during June 2018-May 2019 within the Emissions Trading Scheme (ETS). Subsidies cannot be seen as a perpetual assistance, but are necessary to favour the decarbonisation of energy systems (He et al., 2018) and the explanation of the externalities linked to the environmental advantages linked to the use of PV systems as alternative to fossil fuels can be encourage for investors (D’Adamo, 2018).

Equitable, sustainable and liveable societies are based on the production of energy from natural resources (Zhao et al., 2017). A sustainable transition is required to occur not only at Central Governments level, but also at cities level through
the implementation of a local climate plan (Reckien et al., 2018). Cities have the potential to produce electricity demand for residential, commercial and public purposes, increasing energy security and contrasting the climate change (Bazari et al., 2018). City government plays a relevant role in steering PV deployment and the main obstacles to its development have a political and economic nature represented by high costs that determine long payback period and presence of scarce subsidies significantly influencing the profitability (Mah et al., 2018). The economic feasibility of PV systems depends typically by the share of self-consumption, that is more remunerative than selling of electricity produced (Cucchiella et al., 2018).

The Renewable Decree, called FERs, adopted by Italian Government provides a feed-in-tariff (FIT) system for the photovoltaic production. FERs is not operative because it is being examined by the European Commission and will be operative towards June 2019. This paper proposes an economic feasibility of PV systems realized in public buildings and the assumptions at which these systems become economically viable. Discounted Cash Flow (DCF) is used as economic method and two indexes are proposed: Net Present Value (NPV) and Discounted Payback Time (DPBT). FERs gives a priority to hospitals, schools and public buildings and FIT is recognized for a minimum size of 20 kW. The value of FIT is equal to 105 €/MWh (referred to the energy produced and fed into the grid) and an additional premium tariff equal to 20 €/MWh (referred to the energy produced and consumed) is considered for a period of 20 years. Several scenarios are proposed in order to evaluate the impact of the share of self-consumption and additionally, two plant sizes (20 kW and 60 kW) and two different levels of insolation (North Italy and South Italy) are investigated. The analysis will be completely considering also the variation of investment costs and the electricity purchase prices.

Keywords

economic analysis; photovoltaic; public offices; subsidies

The challenge of implementing sustainability practices under the Sustainable Development Goals approach in corporate activities

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Abstract

As population and demand continue to grow, the complexity of the problems of allocation of resources to address such needs is key to determine whether a sustainable approach is performed or not. A sustainable approach understood as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987).

In 2015, the United Nations (UN) adopted the Sustainable Development Goals (SDGs), publishing 17 goals aiming to end poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda, the so called “2030 Agenda for Sustainable Development” (UN, 2015). The SDGs promoted by the UN are an important step to establish shared global goals for sustainable development over the next two decades, and they represent an evolution in the approach of how sustainability may be addressed (Dang et al., 2019; LeBlanc, 2015). The SDGs take a step forward to the evolution of sustainable development explaining the necessity to consider the people, the planet, the prosperity, the peace and the partnership as a basis to reach sustainable development (UN, 2015). LeBlanc (2015) explains that these goals recognize the interrelated nature of sustainability issues such as poverty, inequality, gender equality and ecosystem conservation, as well as the necessity for all societal actors to jointly tackle them. Consequently, governments, civil society, and the private sector have been challenged to adapt to a new sustainability paradigm.

It is undoubted that to reach the ambitious goals of the 2030 Agenda, any corporation regardless of the type of business or size must endorse a sustainable development approach. Companies, therefore, are explicitly encouraged to adopt responsible practices and report on sustainability impacts (Goal 12.6) and to collaborate with governments and civil society for the achievement of the SDGs (Goal 17).

Enormous efforts are being made by private sector organizations to achieve competitiveness in order to outlast in an always changing context, where environmental concerns, sustainable development and social demands, among others, should be considered in the competitiveness equation (Engert et al., 2016). According to Drucker’s explanation (1954), a sustainable company is the one that improves the quality of life of people with whom it interacts, generates profit for shareholders and at the same time protects the environment. This statement is the basis that defines Corporate Social Responsibility (CSR) and currently sustainability corporate practices.

However, according to Schönherr et al. (2017) finding ways to address the SDGs is hindered by a fundamental difficulty: knowledge of the actual impacts of sustainability practices on sustainable development are limited. Effectively measuring and managing sustainability practices impacts is no easy task; for instance, socio-ecological effects of business activities materialize along complex pathways in different rates, impacting divergently to diverse stakeholder groups and involving trade-offs that can be daunting to assess. On this strand, Whiteman et al. (2015) explain the necessity to expand confines of
companies’ actions “towards their role in the larger ecological system as one of the main challenges for future management research on sustainability”.

Indeed, the SDGs, their targets and their indicators are not simple and easy to interpret, address and evaluate. Currently, the formulation of the SDGs is too subject to interpretation and the utilization of different assessment and measurement methods can lead to different conclusions on the achievement of the SDGs. Moreover, one of the main issues is that many goals are complementary, some even contradictory (Dang et al., 2019).

The accomplishment of an effective sustainable practice relies on employing suitable sustainability assessment methods. Regarding companies’ behavior, literature fails to contribute with methods, approaches and frameworks which would serve to assess the effects or impacts of sustainability practices on achieving SDGs (Milne & Gray, 2013; Giannarakis & Theotokas, 2011; Oetzel & Doh, 2009). In fact, it has been stated that the triple bottom line and the Global Reporting Initiative are insufficient conditions for organizations contributing to ecosystems homeostasis (Starik & Kanashiro, 2015; Searcy, 2016). Moreover, Schönheir et. al (2017) state that the sustainability concept still focuses on “what companies do, rather than on what they achieve in terms of sustainable development”, justifying the urgent necessity to develop guiding approaches for companies to translate SDGs into practice.

This paper focuses on the problems that companies, especially SMEs, or public administrations face in implementing SDGs. Indeed, any organization which wants to manage the implementation of SDGs is faced with the complexity of taking into account 17 major goals, 169 targets and 310 indicators. Then, the great difficulty that an organization must face, in terms of time, resources, and competences, lies in establishing the priorities with which to address these issues. Although giving priority to the implementation of some SDGs certainly helps the enactment of other ones - for example, reducing poverty has a positive impact on the health, education and well-being of citizens - other SDGs might be in conflict with each other. For example, there is certainly a conflict between the second goal, ending hunger in the world, and the fifteenth goal, which promotes the sustainable management of forest and other land resources.

For the previous reasons, even if the acquisition of reliable data and the choice of reasonable objectives can help, the challenges of sustainable development are numerous and difficult to overcome if structured approaches are not designed. Following this lead, after carrying out a careful analysis of the literature on the subject, the paper intends to propose a multi-criteria method with the aim of supporting companies, especially SMEs, or public administrations in the implementation of SDGs.

**Keywords**

Sustainability indicators; environmental assessment; Sustainable Development Goals; Agenda 2030; Corporate Social Responsibility.

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**Method of performance evaluation of the Light Wood Frame construction system: an incentive to use of wood as a sustainable material**

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**Abstract**

Agenda 2030 established by the United Nations (UN) shows concern towards to more sustainable development actions around the world. Of the 17 Sustainable Development Goals (SDG) addressed in this agenda, objective 11 is related to the search for more sustainable cities and communities. In order to contribute to this, this study structured a method to evaluate the performance of constructions based on the light wood frame construction system. The established method based its structure in five dimensions, which involve criteria and subcriteria that analyze technical, social, environmental and economic requirements to evaluate buildings. There are several methods to evaluating the performance of a building; however, there is a lack of methods to evaluate specific building systems. This unprecedented method was built with representatives of the supply chain of the construction system in Brazil. Qualitative tools were used for its construction, such as questionnaire and the Delphi technique, to select the specific criteria for the system, and finally, statistical tools were used to group the criteria and generate weights. The proposed method can be applied during the life-cycle phases of the building, such as pre-occupation, occupation and post-occupation, and then those phases can be compared to measure the performance of the building over its life cycle. This established methodology could serve as a basis for other countries to use the method and thus measure their performance and opt for more sustainable constructions.

**Keywords**

Sustainable buildings; light wood frame; performance of buildings; method of evaluation performance of buildings; Brazil.

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**A discussion about Science, Technology, Engineering and Mathematics Education in the university R&D and its impact on the innovation and environment ecosystem**

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Abstract
Research & Development is strictly connected to STEM (Science, Technology, Engineering and Mathematics) at universities, which has an essential contribution to environmental studies, but also to the growing emergence of startups, entrepreneurs, large companies and new enterprises that have stimulated great efforts in recent years to seek new business and reinvent existing processes and services. Besides, universities provide human resources to organizations, and recently, university rankings have emerged to measure university performance in multiple dimensions. The popularization of rankings has generated a growing influence of their results on stakeholders in the academic environment. This study aims to: (i) compare Higher Education (HE) Institutions with the best performance in rankings among the areas and disciplines related to STEM; (ii) evaluate its favorable ecosystems that are responsible for new products, processes, startups and other business models, likewise the growing investments in venture capital and university and college endowments; and (iii) identify the efforts being made by STEM to contribute to blue and green economy development. Data from main university rankings were collected and compared with innovation and sustainability reports from significant organizations that gather and analyze information related to innovation, social, environmental and economic policies. The expected results of this article are that colleges and universities that produce high-impact outputs related to STEM Education are in environments with favorable indicators related to economy, innovation, conservation and maintenance of environment.

Keywords
STEM education, Research & Development, Innovation, Green and Blue Economies.

Three product development models applied in an integrated way in the design of sustainable products
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Abstract
Nowadays companies that develop products to maintain their business strategies satisfactorily have sought improvements in their development processes through the maturity of their design processes, focus mainly on their users, and the preservation of the environment whenever possible. In this way, this research applies three PDP models simultaneously in an integrated way in the development of sustainable products, they are: i) Strategic Planning Model for the Sustainability Integration in the Product Development Process (PEPDIPS) which aims to guide, facilitate and accelerate the sustainability integration into the PDP through the organizational improvement of the company based on the maturity evaluation of five parameters (organization, organizational, motivation, strategy, and partnership); ii) Human Needs Model (HUNE) is based on the concepts of product design and development focused on the human being, contemplating the application of methods of ergonomics, usability and user experience. This model is composed of 4 phases (identification of opportunities, definition of design strategy, development, analysis of the product in use); and iii) Biomimicry and Sustainability Model (BIOS) which has 6 phases (identification of the opportunity, definition of the problem, generation of solutions, selection of the solution, definition of the concept, specification of the solution). This model is based on the concepts of biomimicry as a tool to support decision making in the process of designing sustainable products, helping and encouraging the use of nature as a source of inspiration for product design with a focus on sustainability. The integrated application of these three models was used in the development process of two cases that presented promising results from the organizational improvement of the company, the user usability and ergonomics and the support obtained from biomimetic concepts.

Keywords

Carbon and Ecological Footprints of the Gypsum Calcination in the State of Pernambuco (Brazil)
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Abstract
Anthropogenic activities have generated a high release of greenhouse gases (GHG), mainly carbon dioxide (CO₂), which occupies about 75% of the GHG amount of the planet (Rahman et al., 2017). This scenario has had global attention on climate change, notably stemming from the effects of accelerating global warming. During the period from 1970 to 2010, the Intergovernmental Panel on Climate Change (IPCC) surveys show a greater than 80% increase in GHG emissions, while anthropogenic pressures on the environment became stronger. In this way, the reduction of GHG emissions is a subject of constant debate in the international community (Chen and Chen, 2017).
In Brazil, Ecological Footprint studies are still well off, and there are many gaps to be understandable. Among these is the quantification of the impacts of various productive activities, such as the production of plaster. The state of Pernambuco is responsible for almost the entire Brazilian production of this product (Silva, 2015). The activities of extraction, processing and production of gypsum by-products represent the main source of employment and income generation in this region. By 2014, the Pole consisted of 42 gypsum mines, 174 calcination industries and 748 precast industries in operation. The sector’s revenue in 2013 was approximately US$ 50 million, and was generated by 13.9 thousand direct jobs and 69 thousand indirect jobs (Sindusgesso, 2014).

In the production of this material, the raw ore of the gypsum is submit to high temperatures to undergo a process of dehydration and transformation in the final product, gypsum. In this stage, which is called calcination, are the main CO₂ emissions of the entire production stage (Fort and Cerny, 2018). Several impacts are reported in the gypsum production chain, especially the significant CO₂ emissions during the crude ore calcination process. In this context, in an innovative way, this paper associated the use of two environmental indicators; Carbon Footprint and Ecological Footprint, for this stage of the productive process. A production of 4,500,000 t year⁻¹ of gypsum and the use of four different energy matrices: firewood, petroleum coke, fuel oil and natural gas was took as a basis. Significant values of CO₂ emissions were observe, with annual values of 914,877,054 tons.

According to Coelho Junior et al. (2018), some studies in the scientific literature disregard CO₂ emissions from firewood burning. However, it should be considered that, without proper forest recovery of the areas from which this material was extracted, biogenic emissions of carbon dioxide have the same global warming potential as CO₂ from burning fossil sources (Okoko et al., 2017). This situation is verified in the Araripé plaster pole, where the firewood is extracted from the Caatingas, for the most part, without great efforts for the recovery or management of the exploited areas. This scenario is an important limiting factor for this productive sector. The use of natural gas, an input that represents 0.2% of the energy matrix, was responsible for the emission of 738,992 t. of carbon dioxide, corresponding to 0.08077% of the total amount. These values show the lowest relation between quantity used and CO₂ emission for this matrix. Most gypsum-producing countries use natural gas as an energy source in the calcination step (Gürtünk and Oztap, 2016; Suárez et al., 2016), because of the high energy-efficiency and the cost and benefit when compared to the other matrix, mainly. In addition, this fuel has a low carbon content, due to its higher hydrogen-carbon ratio, which implies a lower release of CO₂ into the atmosphere (Johnson et al., 2017).

The Carbon Footprint ranged from 32.844 to 244.319 kg CO₂t⁻¹ of calcined gypsum depending on the energy source used. However, due to the predominance of firewood use, the total Carbon Footprint was 237.104 kg CO₂t⁻¹. The biologically productive areas required for the absorption of CO₂ released in this process, expressed as Ecological Footprint, amounted to 207,505,227 gha, the equivalent of 6,093 gha·t⁻¹ of calcined gypsum. Based on the difference between and the local biocapacity (165,009.38 gha) and the Ecological Footprint, an ecological deficit scenario (44,495.85 gha) is observed. The results show the unsustainability of this productive sector and the urgency in its suitability aiming at the improvement of environmental quality. In the search for better environmental metrics and reduction of the analyzed indicators, actions aimed at the use of a sustainable energy matrix should be considered. With the search for a more sustainable energy matrix, gypsum produced in the state of Pernambuco, northeastern Brazil, may try to be sold in countries with higher socio-environmental requirements, increasing the market capacity of this product.

**Keywords**

Sustainability indicators; Sustainable development; Improvement of gypsum.

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**Environmental Perception of Family Farmers of Pernambuco Semiárid (Brazil)**

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**Abstract**

For Roos et al. (2018), is understood as ecosystems immediately above and on both sides of the river banks, including flood terraces, which interact with the river in periods of flooding. According to Poester et al. (2012), this type of ecosystem is of great relevance since it has a set of ecological functions fundamental to the quality of life, especially with respect to local populations and the river basin, and are therefore essential to maintain the conservation of diversity (aquatic and terrestrial) of the region. Ribeiro et al. (2012) and Nunes et al. (2019) emphasizes the ecological importance they exert in the environment, being considered Areas of Permanent Preservation - APP by the Brazilian legislation in Article 3 of Law n. 12,651 (BRAZIL, 2012) it’s ‘protected area, covered or not by native vegetation, with the environmental function of preserving water resources, landscape, geological stability and biodiversity, facilitating the gene flow of fauna and flora, protecting the soil and ensuring the well-being of human populations’. However, anthropogenic actions are reaching APP intensively (ARAÚJO, 2012; SILVA et al., 2017; ZIMBRES et al., 2008), since they have been the target of all kinds of degradation (FERREIRA; DIAS, 2004; HALIK et al., 2019). Moreover, many cities were formed on the banks of the rivers, eliminating riparian vegetation (RICHET et al., 2017).

The riparian forests, in addition to those provided by the Brazilian Law as Permanent Protection Areas, are particularly important spaces because of ecosystem services linked to the maintenance of environmental quality. However, these are under impacts from the most diverse human activities. The municipality of Ibirítiri, located in the semi-arid region of
Pernambuco, northeast of Brazil, where the Moxotó river is present, has the second most profitable activity in agriculture. This is practiced by farmers who integrate the Moxotó Irrigated Perimeter (Pimox) and by family farmers. Both use the banks of the river for the development of agriculture and livestock. The present article studies the environmental perception of these farmers on aspects related to the riparian forest, aiming to help the structuring of mechanisms and conservationist policies. The data collection began with bibliographies and the application of semi-structured interviews, analyzed by the Statistical Test of the Chi-square of Adherence. The results showed that the farmers’ environmental perception about these subjects presents distortions of understanding when compared to scientific knowledge. There is a need for public policies aimed at sensitizing this community to increase the degree of scientifically based knowledge of these, as well as the discussion for the identification of conservation strategies for the semi-arid region of Brazil.

The family farm workers of the municipality did not present a good environmental perception of the aspects related to the riparian forests, since of the subjects covered in the questionnaire, most of the interviewees did not understand well. The concept of riparian forest and the relevance of this were the issues most understood by farmers, environmental services and Law 12.651 presented the highest percentage of incomprehension. Therefore, it is necessary to adopt public policies to raise the awareness of the community, since these are social actors that modify the riparian forests of Pimox and need the natural resources to practice daily activities in agriculture. The Public Policies based on the principles of Environmental Education have proved to be a viable tool to be applied in the region, since this mechanism seeks to raise awareness and increase the level of criticality of individuals in relation to environmental issues. However, more detailed studies about the perception of the resident community in the municipality of Ibirimirim, not only of family farmers, are necessary, since these are also agents acting in the environment. In-depth research into the most efficient methods of applying public policies, taking into account the local reality, must also be carried out with the aim of achieving a more sustainable management.

**Keywords**

Environmental Management. Sustainability. Public Policy

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**The impact on waste management performance of corruption and other crimes against the public administration: an empirical investigation in Italy**

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**Abstract**

Corruption and other crimes against the state, public governments, and public institutions are impactful events for efficacy and efficiency of public service provision in developed and developing countries, altering attractiveness for national and foreign investment, investment realization, productivity and technological change (Abrate et al., 2015 and reference therein).

According with Transparency International “Corruption is the abuse of entrusted power for private gain” (Transparency International, 2009). Along with corruption, embezzlement, concussion, abuse of office and other crimes against faith and public order should be accurately monitored and managed in order to decrease their potential impact on economy, accountability, wellbeing, environment and sustainability.

Among European countries, Italy results usually at the bottom of international rankings about corruption, integrity and bribery such as the Corruption Perceptions Index - CPI (Transparency International, 2018), the Corruption Control Index – CCI by the World Bank (2019), the Bribe Payers Index – BPI (Transparency International, 2011), the Index of Public Integrity (IPI), developed by ERCAS (European Research Centre for Anti-Corruption and State-Building), where Italy ranks 22 out of 28, 20 out of 25, 7 out of 7, and 19 out of 25, respectively. Moreover, the Global Corruption Barometer (GCB) settled by Transparency International (2016) stated that Italy is among the most critical European countries, where more than 7 out of 10 citizens perceived that the government is doing a bad job at fighting corruption in government.

With reference to corruption perception, in 2017 the Italian National Statistical Institute (ISTAT) published a report (ISTAT, 2017) where emerged that 7.9% of Italian families has experienced at least a corruptive event and that a high heterogeneity exists among Italian regions.

Along with subjective index, based on citizens’ perceptions, other measures of corruption and crimes have been used. Golden and Picci (2005) used “the difference between what government cumulatively pays for public infrastructure and the physical quantities of infrastructure that exist”. The Authors aimed to measure, all else being equal, what governments do not get from what they pay retaining that this difference is public money that bureaucrats and politicians are getting from corrupting transactions$^5$.

In this context the waste industry is particularly suited to be investigated for analysing the impact of crimes against the public administration on its performance. As highlighted by the Italian National Anticorruption Authority (ANAC), in Italy waste management is characterized by a particular regulatory and organizational complexity due to the variety of institutional levels involved and the intrinsic technical complexity of the legal framework. The waste management is particularly critical in all the Italian areas (North, Center and South) since it is affected by a persistent fragmentation, in spite of the integrated system proposed by the normative framework, and by the risk of attracting the attention and interest...
of criminal organizations, due to the considerable economic importance of the sector (ANAC, 2019).

Municipal solid waste collection and disposal is a public service that has been extensively studied. Waste reduction and recycling through waste separation are the most relevant strategies settled by regulators and applied by decision-makers to meet the environmental targets (Struk, 2017; Romano et al., 2019). Although the impact of corruption and other misconducts against the public administration has been studied with a focus on the waste industry from some scholars (Abrate et al., 2015; Agovino et al., 2018), no previous studies have investigated the potential impact of these misconducts on waste reduction and recycling, intended as targets settled by the national legislation and the EU framework as well as good environmental practices for sustainability reasons.

In accordance with Abrate et al. (2015), Yan and Oum (2014) and Del Monte and Papagni (2007) we use as measure of corruption and other crimes against the public administration the number of public officials convicted of such practices and misconducts for each of the 20 Italian regions for a ten-year period (2008-2017). Since corruption and other misconducts against public administration are social practices and behaviours that could be affected by the relational context in which they happen (Vannacci, 2017), we control also for the impact of them on waste management performance by collecting data from public sources about the regional contexts including variables such as population density, regional size in terms of number of residents, age of residents (measured using the old-age index) and the administrative fragmentation in terms of the number of provinces in which each region is divided.

Using panel data regression, we found that both waste reduction and recycling are affected by the numbers of crimes against the public administration, so that the more the public officials convicted for misconducts, the higher the production of waste and the lower the separate collection rate.

The main limitation of the study is the measure of crimes against the public administration chosen: as highlighted by Abrate et al. (2015), considering only those crimes reported to the police and to the judges has the drawback of underestimating the true phenomenon. Unfortunately, data about perception are collected and provided from ISTAT only for a year (ISTAT, 2016) and do not allow the use of subjective indicators in the analysis. So, further research is needed to add data about perceptions of corruption and other misconducts.

**Keywords**

Corruption, Waste management, Environment, Sustainability

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**Numerical Investigation of the Decoupling Combustion Characteristics of a Novel Low-NOx Burner for Low-volatile Coal**

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**Abstract**

A significant portion of coal produced in China is of low grade with low volatility. Therefore, in China, reserves of low-volatile coal (mainly including lean coal and anthracite) are widely utilized in coal-fired power plants and supply a considerable proportion of current electricity demands, approximately 10%, 2. Kurase et al. 3-6 found that it is challenging to maintain a stable flame, high combustion efficiency and low NOx emission with low-volatile coal. Nowadays, down-fired combustion is widely applied in the power industry to consume low-volatile coals, and its main merits are that the high-temperature level and the prolonged residence time of pulverized-coal, which allow for the use of coal with low volatility and poor reactivity.7 The practical low-volatile coal-fired boiler operation still suffers from high carbon content in the fly ash and poor flame stabilization at low load without oil support firing8, 9. Nevertheless, since more and more fluctuation of electricity consumption, more importantly, to assist the renewable energy generation, the boilers peaking operation should be more flexible and even be operate under low load conditions frequently. However, despite the utilization of air-staging combustion, the high-temperature causes NOx emissions increase considerably, which reaches approximately 1100–1800 mg/m3 (O2 at 6%)10. Therefore, there is still a necessity to further improve the low-volatile combustion technology of high stable combustion and low NOx emission capacity simultaneously.

This study applied the 3D numerical simulation on the analysis and optimization of a novel decoupling low-NOx burner for low-volatile coal. The stable combustion ability of low-volatile coal and its low-NOx principle of this burner were analyzed in detail. Research findings indicate that the separators of this burner showed 3 staged coal/air separation, and the flame holder’s structure resulted in advantageous low-volatile coal ladder-shaped spontaneously steady combustion and enhanced decoupling combustion with low-NOx emission. The main reason for the optimized DLNB burner showed outstanding low-NOx properties was the long and robust penetrated char bundle formed, surrounding by wide range of reducing atmosphere, which enhanced the decoupling combustion condition. To optimize this burner, different central plate structures were compared. Finally, the structure of a flat plate without inclination showed good performance in all the aspects including the flow field distribution features, rich/lean separation properties, combustion characteristics, and NOx generation. Its rich/lean flow quantity ratio was 0.85, rich/lean concentration ratio reached 22.94 and ultimately the average NOx concentration at the outlet was only 552.52 ppm, which compared with the initial design structure, reduced
by 60%. The results facilitate a better understanding of the novel low-NOx burner and provide technical support for its future application.

Keywords
Low-volatile coal; Numerical simulation; Low-NOx combustion; Stable combustion; De-coupling combustion

Value Proposition and Value Creation in Circular Economy Business Models: a study of micro and small fashion retail companies in Brazil
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Abstract
Besides its economic importance, the fashion industry is known as having severe impacts, both in the environmental and social aspects. While the traditional approach concerning environmental issues has been on achieving efficiency to reduce, avoid, minimize or limit the impacts of companies’ activities, new ways of dealing with sustainability can extend the benefits to society and reduce the harm to nature, such as Circular Economy (CE). This paper aims to identify how the concept of circularity has been applied to fashion retailers’ businesses models. This aim is twofold: first, we map micro and small companies fashion companies using circular practices in their business models. And, second, we seek to understand firms’ value proposition and value creation according to the typology of the circular business model by Lüdeke-Freund, Gold and Bocken (2019) typology. To do so, we explore the definitions and characteristics found in the literature within the reality of the fashion retail sector to expand the understanding of the existing theory on Circular Economy Business Models (CEBM). In this qualitative research, we have used the multiple case-study method. The cases are micro and small companies fashion companies identified as using circular practices in their business models. The cases are micro and small companies fashion companies identified as using circular practices in their business models. The main findings indicate that companies present different sets of value proposition and creation configurations and that not all the configurations proposed by the typology were found. We also discuss the possibilities of other configurations given the specificity of the sector in the study. In this way, the study contributes academically by reducing the gap of the literature on circular business models. From the clarification of the main characteristics and implications of a CEBM. Besides it, the paper will contribute to the characteristics of the CEBM operating in a specific sector of a developing country such as Brazil.

Keywords
Sustainability; Circular Economy; Business Models; Circular Business Models; Fashion Industry.

Scenarios for resource use optimization in the construction and operation of a university health services building in an arid zone in Mexico
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Abstract
The construction sector consumes between 20 and 50% of the physical resources of its environment and approximately 40% of the primary energy during the use of the buildings. Construction in desert zones represents a significant problem. Buildings in these climates commonly consume a lot of energy through artificial air conditioning systems; therefore, they need ingenious bioclimatic design strategies to reduce it. The lack of water in arid zones is another issue that affects most of the Sonoran Desert in Mexico and poses difficulties in supplying water to the nearby cities in the state of Sonora, particularly its capital, Hermosillo. The aim of this article is to provide elements for decision making related to materials and equipment selection during the planning and architectural design process on the energy and resources consumption of the buildings, relying on Building Performance Simulation software, for a building prototype for health services promotion within a university campus in hot-dry weather. The following simulation tools have been used: Optimization energy for Autodesk Revit® as well as CALTER® by the Autonomous University of Baja California. The results of the tools were compared with each other to facilitate decision making and energy optimization in the architectural project. It is estimated that an optimized design scenario, savings in electricity consumption compared to the traditional construction of the region can be higher than 40% and the reduction of water consumption could reach more than 30% with appropriate rational consumption strategies. This project attends a real construction necessity at the University of Sonora, Mexico. However, a project of this type depends on the times and internal processes of the institution. The scope is on the design stage of the prototype and is supported on calculation methods and simulation tools that help to predict the results, and with that information make better designing decisions, including the selection of materials and equipment. A process of analysis and design of this type could be a useful way for the university and other higher education institutions to develop infrastructure that reduces the consumption of electricity and water, with the consequent economic savings and reduction of environmental impact.
Keywords
sustainable construction, desert, energy efficiency, water consumption, Mexico

A copula-based multi-level optimization approach for industrial structure management in the background of energy-intensity mitigation
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Abstract
The management of energy resources is an integral component of regional economic development and environmental protection. In order to support industrial structure management against a background of energy-intensity mitigation, an integrated approach was developed through incorporating copula function and Markov Chain Monte Carlo (MCMC) simulation in the framework of multi-level optimizing model. The approach could improve previous studies in systematically reflecting the relationship between energy consumption and economic benefits, and supporting regional management based on stakeholders of multiple levels (i.e., levels of district, city, and urban cluster). Also, this approach can be applied to support decision making about promoting manufacturing sectors of made in China (2023). The developed method was then demonstrated in the urban cluster of the Pearl River Delta, including nine cities of Guangzhou, Shenzhen, Zhuhai, Dongguan, Huizhou, Zhaoqing, Foshan, Zhongshan, and Jiangmen. Concurrently, multi-level uncertainties in industrial structure management for the urban cluster can be effectively addressed. The results indicated that under the desired industrial structures, violation risk of energy-intensity mitigation would be indistinguishable in the level of the urban cluster. Also, the cities of the urban cluster would achieve the goal for developing the manufacturing sectors, based on their Industrial Plans for the 13th Five Year.

Keywords
Industrial structure management; Copula theory; Multi-level optimization; Energy-intensity mitigation.

Urban growth and energy transformation hierarchy: a modelling proposal to estimate fractal structure for urban aggregates
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Abstract
The limits of growth is a prominent topic that was and still is important as subsidy for public policies in the most different themes and scales, including urban agglomerations. Understanding how cities grow or how they are organized, distributed and connected are important since their sustainability is being revealed as low, because they are highly concentrated spaces that demands matter and energy from their surrounding neighborhood. On the other hand, cities provide such high quality outcomes as knowledge, high-tech goods, and they usually feature the most important offices including administrative, financial, legislative, and judiciary ones. This claims for efforts in understanding the balance between advantages and disadvantages of cities towards a green and blue economy.

Considering that “growth of large urban aggregates is analogous to the development of self-organized structures know in physics” (Schweitzer and Steinbrink, 1998 pg. 69), the complexity of cities can be studied under simple rules, among others, the fractal structure (or scaling exponent) of cities can be an important indicator to understand how they are spatially organized. The use of fractals is also supported by Chen (2014), whom states the hierarchy of cities as similar to the fractal of cities. Fractals can be estimated by different approaches, but usually it is based on measures of area, population, GDP, among others, all them obtained from a temporal analysis.

Currently, energy accounting is being suggested as an alternative tool in representing the limits of growth for cities (Agostinho et al., 2016), since energy embraces important aspects as a donor side perspective in supplying resources (which recognizes the important of those energy flows without market value) and the concept of energy quality, which is represented by its unit energy values. According to Odum (1996 pg.174), the empower density (i.e. energy per time, an energy concentration value) can be used to represent the aerial energy transformation hierarchy in a map form, indicating how energy is regionally concentrated. In this sense, empower density could be used as the physical characteristic of cities to support fractals calculations. Although a promising alternative in calculating fractals rather than using area, population, GDP, etc., the empower density of cities are scarcely found in literature or even datasets, and it becomes worse when a temporal analysis is needed. This lack of available data claims for methodological alternatives in estimating empower density of cities under an accurate and fast way. Recently, Neri et al. (2018) proposed the use of night-time lights images to estimate the non-renewable empower for regional analysis. Using satellite images to calculate the sum of lights index, authors have found an accurate estimation of non-renewable empower at country scale. In parallel, after the work of
Agostinho et al. (2010), Mellino et al. (2014) proposed a way to calculate the renewable part of empower for regions using maps with the spatial distribution of solar radiation, heat flow, wind-kinetic energy and precipitation. These methodological alternatives could be used as a good proxy in estimating the empower density of cities under a temporal analysis, including both, non-renewable and renewable energy fractions.

Considering the importance in obtaining the fractals of urban aggregates to discuss their growth patterns, this paper aims to propose a procedure to estimate such fractals based on the energy hierarchy represented by the empower density values. To illustrate the proposed procedure, the 645 cities of São Paulo state, Brazil, are considered as case study. Satellite imagery VIIRS from NOAA National Geophysical Data Center, NASA (http://ngdc.noaa.gov/eog/viirs/), year 2013, are used under the software ArcGIS 10.1 for database mathematical operations and maps elaboration.

The main contribution of this study is the proposed procedure to rapidly calculate the fractal of urban aggregates, based on the empower density recognized as a robust value in indicating the real value of goods. This kind of information would be useful for deciders towards more sustainable cities. A step forward will be applying the proposed procedures in the 645 cities of São Paulo state through different years to allow the calculation of a representative fractal, supporting discussions about São Paulo cities growth patterns.

Keywords
Cities, Energy, Energy hierarchy, SIG.

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Life cycle assessment of hydrogen-based buses for public transportation in cities
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Abstract
The intense use of fossil energy during the last century has, mostly, negatively affected the economy (i.e. through political-financial pressures and wars), the environment (i.e. global warming) and the society (i.e. respiration and cardiovascular health issues), which added to a scenario of scarcity for fossil energy in short-time period highlight the need to break the human addiction to fossil energy. Among several other uses, the transport of people plays crucial role towards a reduction on human fossil energy dependency.

Efforts aiming to propose energy alternatives are largely found in literature, each one with its own purposes and scope. Specifically for the public transportation, the city of São Paulo, Brazil, has experienced the use of hydrogen as energy source for public buses (Fuel Cells Bulletin, 2009; Neves Jr. and Pinto, 2011). Hydrogen is one of the most abundant elements on the planet and can be obtained from numerous sources, such as water, biomass, natural gas, ethanol, among others. The installed project in São Paulo city generates hydrogen from electrolysis (using electricity + water), which is stored and then feed the buses that convert it into electricity. At principle, the project has been called as sustainable or green since it does not depends on fossil energy – hydropower correspond about 70% of electricity matrix in Brazil – and because the bus exhaust releases exclusively vapor of water. Anyhow, the installed project still demands resources that can cause upstream impacts be on the equipments and machines demanded or even on the water used (i.e. origin, quality, etc.) by demanding pumping and treatment, and electricity generation and transmission. All the entire productive cycle should be accounted for to represent a more accurate picture about the environmental performance (regarding emissions) of the installed project.

This work aims to apply the life cycle assessment (ISO 2006a, 2006b) method on the installed project in São Paulo city to generate and use hydrogen for public transportation in buses. System boundaries contains hydrogen production and storage in the filling station as well the bus itself consuming hydrogen and transporting people. The functional unit considered is kilometer travelled (1 km). Impacts are calculated from different points of evaluation: for the mid-point, the CML2001 method is applied to estimate global warming potential (GWP100) and the acidification potential, while the cumulative energy demand method is used to estimate the non-renewable energy demand; for the source-point, particulate matter (2.5-10 μm) is calculated due to its impact on human health. They were chosen because represent the most significant impacts caused by burning diesel in combustion engines, additionally, they are considered as goals for reduction according to the European Emissions Standards (Euro VI) that defines the acceptable limits for exhaust emissions in vehicles; in Brazil, Euro VI deadline is 2023. Results will be compared to the Euro VI targets as well with published data on diesel burning.

It is expected that, according to the Brazilian conditions, the indicators obtained from LCA for the hydrogen fuel in public transportation will show better performance than for diesel, which would support its usage. A step forward will be to evaluate a scenario of complete replacement of current 6,000 diesel-based public buses in São Paulo city with hydrogen-based buses. The main purpose is to verify whether this substitution will be able to accomplish the emissions reduction as proclaimed by Brazilian public agencies.

Keywords
Hydrogen, LCA, Urban mobility.
A two-tiered attribution structural decomposition analysis to reveal drivers of CO2 emissions in the Yangtze River Economic Belt at both sub-regional and sectoral levels

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Abstract

As the world’s largest inland shipping channel, the Yangtze River Economic Belt (YREB) is the prior region for achieving China’s strategic development with both economic and ecological goals. With the increasing emphasis on achieving the national target of CO2 emissions, it’s important to identify drivers of CO2 emissions in the prior regions of China, especially in the YREB. However, previous researches are relatively rough and mainly focusing on the overall effects of drivers on CO2 emissions changes, while neglecting the sub-regional and sectoral level effects. Nevertheless, such refined researches will provide more targeted policies for emissions reduction. Integrating the method of structural decomposition analysis with attribution analysis, this study conducts a two-tiered attribution structural decomposition analysis to reveal drivers at both sub-regional and sectoral levels, for emissions changes of the YREB during 2002-2012. Results show the following, (1) Jiangsu Province has always been the main region for the increasing of CO2 emissions in the YREB, accounting more than 20% of total CO2 emissions growth. (2) The Production and Supply of Electric Power, Steam and Hot Water (EGW) sector owns the most of CO2 emissions increment both in 2002-2007 (609.8 Mt, 55%) and 2007-2012 (287.6 Mt, 34%). (3) FGH2 emissions are the primary driving forces of the increase in CO2 emissions with 1517.72 Mt in 2007-2012, accounting for 79.39%. While CO2 emissions intensity dominates decline of CO2 emissions for -1012.7 Mt (2007-2012). (4) Moreover, the emissions intensity in the Anhui province, Production and Supply of Electric Power, Steam and Hot Water (EGW) sector accounts for 67% (86 Mt), which should be attached great attention to policy-makers. Considering the diverse impact from driving forces, sectors contribution and regional contribution, policy makers need to see a whole map and do appropriate guidance based on CO2 emission reduction targets.

Keywords

Yangtze River Economic Belt CO2 emissions Socioeconomic Drivers Structural Decomposition Analysis Attribution Analysis

Global Oil Price and Innovation: The impact of R&D spending, Oil price and Oil price volatility on Environmental Pollution in Oil exporting and Importing Countries.

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Abstract

Recently, the issue of sustainable economic growth has gained the front line of the global development agenda. The common dependency on fossil fuel energy, the GHG emissions increase and the continuous raising demands for energy created global challenges that put the world in a trap of climate change. Achieving sustainable economic growth requires the stabilization of GHG emission within the acceptable threshold level. This work analyzes the implications of innovation, oil price, oil price volatility, economic growth on global GHG emission over the period 1991-2015. The study made comparisons of emissions between oil consuming and oil producing countries, using the newly enhanced panel VAR model. The main empirical results point positive implication of innovation in reducing GHG emission in oil importing economies. Contrarily, innovation exacerbate the increase in GHG emission in oil exporting economies, denoting perverse impacts of innovation on the GHG emission in oil exporting countries. Similarly, the study identifies broader implications of oil price and oil price volatility on GHG emissions. Oil price volatility shows asymmetrical impacts on GHG emissions, indicating negative relationship between oil price increase and GHG emission in oil importing countries. However, GHG emission increases with oil price increase in oil exporting countries, exacerbating the global emission curtailing mechanisms due to oil price increase. Unlike the oil price, the international oil price volatility has nearly similar decreasing effects on GHG emission between the exporting and importing economies. Thus, one might be tempted to take the volatility and future oil price uncertainty as virtuous instance to decrease GHG emission. Regardless of the classification of the economies, economic growth has positive impacts on GHG emissions in the short-run. However, in the long-run the effect is negative and benign to decrease the environmental pollutants. The results are robust, and provide the different policy, and market scenarios in oil importing and exporting economies. Failing to account the innovation, oil price and price volatility effects may screen both the appropriate GHG emission- mitigating mechanisms and effects of the pivotal factors in different economic stings. Thus, to ensure sustainable economic growth, we recommend policymakers and researchers to consider the pivotal role of the factors of study in different economic scenarios.

Keywords

GHG emission, sustainable development, economic growth, innovation, oil price
Proposal of a decision support tool for retrofit in municipal street lighting services through use of the concept of eco-efficiency

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Abstract

Urban public service managers gradually learn to incorporate urban sustainability as an element of their decisions. An element of the current moment is The 2030 Climate Agenda with its objective of: making cities and human settlements inclusive, safe, resilient and sustainable. However, there are few analytical tools to support the decision of public agents. The paper will present a proposal for applying the concept of eco-efficiency in the management of public street lighting services and will demonstrate its feasibility as a model for decision making in the sector. To propose an analytical model that allows decisions on the renewal of public lighting infrastructure to ensure greater eco-efficiency in the transition to innovative technologies, in order to mitigate the environmental impacts and their cost of installation, operation, maintenance and decommissioning. The Life Cycle Assessment (LCA) technique and the GHG Protocol tool were used to evaluate the environmental dimension of eco-efficiency. The Life Cycle Cost Assessment (LCC) technique and the tools of Net Present Value, Internal Rate of Return and Payback were used to evaluate the economic dimension of eco-efficiency. This led to a measure of eco-efficiency associated with different solutions presented to the public manager. The model was tested to compare solutions for public lighting in the city of São Paulo. An Analysis Model was developed to evaluate in an integrated way the economic and environmental performance (ecoefficiency) of products and installations for Public Lighting services.

Keywords

urban sustainability, eco-efficiency, street lighting, LCA, LCC, GHG protocol.

Key requirements for building a manufacturing-oriented service development model

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Abstract

Recent changes in the business environment, such as increasing the competitiveness of developing countries, the globalization of markets and new customer demands make it difficult to rely solely on the traditional strategy, which offers only the product without worrying about or appreciating the provision of services (BIKFALVI et al., 2013). According to Alvarez et al. (2015) there is an emerging trend to offer services in many industry sectors.

This growing tendency to offer or aggregate services is motivated by financial, strategic and marketing interests (BAINES et al., 2009a), and/or the results demonstrate an alternative that can differentiate companies from their competitors (ALVAREZ et al., 2015), and/or the interest in the search and fulfillment of customer satisfaction (TUKKER; TISCHNER, 2006; BUSTINZA et al., 2015), and/or the search for more sustainable solutions (ALIX; ZACHAREVICZ, 2012; ARMSTRONG; LANG, 2013).

For Aurich et al. (2010), because of the need for innovative services, service companies as well as products, must focus on services and service-oriented products to maintain and increase their market competitiveness. This evolution results in an extension of the services sector and can also be emphasized by the following trends: customer orientation through product development and service oriented products. Alvarez et al. (2015) argue that transforming typical manufacturing firms into service providers can be considered an important contribution to the creation and offer of new business. According to Oliva and Kallenberg (2003) and Martínez et al. (2010), a typical manufacturing company subjected to servicing requires new principles, structures, operational support and production processes.

Even with the potential advantages, Sutanto et al. (2015) state that there is a clear need for a framework that can be used to determine the list of design requirements for a development process to meet customer needs. In addition, the existing literature offers little advice to product and service providers seeking to design new Product-Service Systems (PSSs) (CLAYTON, et al., 2016). According to the authors, although the existing literature reveals a small number of proposed methodologies, they were not evaluated in relation to an industrial organization that sought to be served.

Several authors have identified in their works the lack of proposals and projects of integration of the areas, such as Baines et al. (2009a), Baxter et al. (2009), Aurich et al. (2010), Sutanto et al. (2015) and Clayton et al. (2016) that motivated the construction of this work, which aims to identify and analyze the main requirements and guidelines for the construction of a theoretical-conceptual model of service development oriented to manufacturing companies.
The approach used in this research was the Bibliographic Review, which has a very important role for the development of the model, taking the form of a systematic literature review and content analysis. Kitchenham (2004) states that the systematic review aims to present an assessment of a research topic using a review methodology that is reliable, accurate and that allows auditing. The systematic review followed three steps: base choices, keywords and period to be analyzed; search of articles and registration by means of software; and pre-selection of articles, bibliometric analysis and content analysis.

The observed results of the systematic review allowed to reflect on the main authors, besides showing to be a current theme and of increasing interest in recent years. Also, an analysis of the key words and main journals was carried out, making it possible to visualize the major areas of research interest in this topic. After these first observations, it was possible to find important elements that emerged from the content analysis, such as the lack of development process and implementation of the PSS presenting operational detail, corroborating once again to have more discussion and development of works in this direction. In addition, some directions were emphasized in the theoretical basis and content analysis, from which the main guiding contexts were extracted in a model and the main research opportunities to be explored.

**Keywords**

New Service Development; Product Development; Theoretical-Conceptual Model; Servitization; Product-Service System.

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**Hydrothermal carbonization of excavated landfill waste for organic pollutant absorber**

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**Abstract**

Despite the high development of alternatives disposal means, the landfill is still the most popular disposal means in the form of open dumping and sanitary landfill. In 2015, UNEP counted that in Asia, 57% of disposal process is open dumping while 31% is sanitary landfill. Incineration and recycling only take 5% and 8% of the total, respectively. While, in Africa, 47% adopts the dumping and 29% employs sanitary landfill.

On the other hand, in North America, sanitary landfill takes 91% of waste disposal method. It shows that most developing countries rely on the landfill as disposal means for their municipal solid waste (MSW) because it cost less than other methods. Cherubini (2009) mention that operation of landfill site does not only lead to decreasing the environmental quality of surrounding area from smells but also at a global scale, the methane released will bring worse effect than CO2 to global warming, thus, a method to minimize the impact while bringing the benefit is urgently necessary.

Several countries have been excavating their old landfill to reclaim the land and recover the valuables (Krook, 2012). Hull et al. (2005) concerned about the cost feasibility of landfill mining since most of the project only works if there is a special fund for remediation and the excavated material could be sold to cement factories as refuse-derived fuel. The quality of recyclable material from landfill mining is very low; thus, the processing cost is higher than usual. Other materials such as soil-like fraction need stabilization for re-used as cover soil (Baskoro, 2018). The transportation issue is also important since most of the landfill is located in a remote area, far from the recyclable processing plant, cement factories, or waste-to-energy plant (Damanhuri, 2008). It will be more effective and efficient if some of the excavated material from the landfill mining project could be reutilized on site.

Hydrothermal carbonization converts cellulosic biomass, industrial waste, and municipal solid waste into homogeneous carbonaceous solids with higher surface area (Sevilla and Fuertes, 2009). The carbonization temperature is ranging from 150-150 °C, depend on the material and the decomposition temperature. Hydrolysis, dehydration, and decarboxylation during hydrothermal carbonization produce high oxygenated functional group hydrochar, which a useful precursor for the production of activated carbon and potentially used as carbonaceous adsorbent (Sevilla and Fuertes, 2011).

The carbonaceous adsorbent is composed of carbon with porosity and surface chemistry characteristics to enhance the adhesion of substances to their surface. Activated carbon is one of the examples of carbonaceous adsorbent which the easiest to produce. Activated carbon is produced by physical and chemical activation, which require pyrolysis before or after the reaction. By employing hydrothermal carbonization before pyrolysis stage in activated carbon production, energy and economic efficiency will increase. Homogeneity of the material will increase, and the production of tars during pyrolysis will also be minimized (Fernandez et al., 2015; Srikanth, 2016).

Fernandez et al. (2015) produce hydrochar from orange peels with surface area ranges from 300 to 630 m²/g. After thermal activation in CO₂ or air, the hydrochar adsorb emerging pollutant (diclofenac sodium, salicylic acid, and flurbiprofen) very well. Bansal and Goyal (2001) present the use of activated carbon to remove organic molecules with different toxicity, abundance, polarity or size characteristics, including phenolic compounds, volatile organic compounds, and synthetic dyes.

Leachate found in municipal landfill contains high organic compound pollutant from the anaerobic reaction, such as volatile acids, proteins, amino acids, carbohydrates, and aromatic hydroxyl compounds (Stanford et al. 1979). Biomass and plastic waste which is abundant in municipal landfill are potential sources for activated carbon. Excavating and converting both materials into activated carbon could increase the efficiency of landfill operation. The reclaimed land could be prepared for new landfill or other building, while the activated carbon could be utilized in a leachate treatment facility.

This study focuses on developing adsorbents through the conversion of excavated landfill waste into hydrochars by
employing hydrothermal carbonization and additional thermal activation. The excavated waste was obtained from landfill in Semarang City, Central Java Province, Indonesia. The excavated waste was sorted by hand into organic, plastic, incombustible, and soil. The samples were stored in vacuum plastic bag then stored in the freezer before further analysis and treatment. Soil like material dominates the composition of excavated waste. The combustible part consists of 18% organic and 27% plastic.

Five grams of excavated waste and 4.45 gr of Mili-Q ultra-pure water were mixed in the reactor tube. The reactor was sealed, purged with argon, then heated to 200-240 °C. The holding time was set from 0 to 60 minutes. After the reaction finished and the reactor cooled down to 60°C, the hydrochar was discharged from the reactor to be filtered and dried at 70°C overnight. The activation process involving pyrolysis in a nitrogen atmosphere with the operating condition between 300-700 °C and 0-2 h holding time.

The activated hydrochar was analyzed for its chemical and physical characteristics. Proximate analysis was done to determine the moisture, volatile, fixed carbon, and ash content of the hydrocar and activated carbon. The ultimate analysis was done to find the weight percentage of carbon, hydrogen, nitrogen, sulfur, oxygen, and chlorine. XRF and XRD were done to understand the elemental composition and crystalline structure. FTIR was done to confirm the presence of the oxygenated functional group. For physical characterization, SEM and BET were done to observe the pores structure and surface area of the activated carbon.

Batch adsorption experiments were performed by using phenol to simulate the organic pollutant in leachate. Different concentration from 0.1 to 20 mg L⁻¹ were used, and water to sorbent ratio was set to 30%- 70% of total solution. To the solution were shaken at 25 °C, 200 rpm for 24 h in the dark. The solution was filtered, and the solid and liquid part was analyzed separately. The liquid part was observed for the change in total organic carbon (TOC) content using TOC analyzer. Decreases in TOC content equivalent to absorbed phenol.

**Keywords**
landfill mining, hydrothermal carbonization, activated carbon, organic pollutant

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**Reflection on the production chain of sustainability oriented products**

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**Abstract**

The Sustainability has been included in the agenda of public and private institutions and society as a whole in the face of the environmental problems facing the planet, starting with the first deliberations established in 1972 at the United Nations Conference on the Environment in Sweden (Brundtland, 1987). Since 1972, United Nations Organizations has discussed the progress of the issue of sustainability in all its editions. In 2017 the United Nations World Commission took a new step towards sustainable development and proposed seventeen-millennium goals to be implemented by 2030. Among the millennium goals, this study highlights the production and sustainable consumption. So, sustainable products are understood as one of the solutions to meet social needs and demands and contribute to a more sustainable environment throughout the product life cycle. The product life cycle refers to the management that considers the entire product cycle, from the initial design phase, through the product manufacturing process, destination (final consumer) to reuse and disposal (Manzini and Vezzoli, 2008). Integrating in this way, all links involved in the production process, called the production chain. So, what are the main researches that approach the theme production chain associated with the product oriented to sustainability? Thus, the objective of the study is to identify the main researches that approach the theme productive chain focusing on the product oriented to sustainability. In order to reach the proposed objective and to answer the research problem, a systematic review of the literature was performed with content analysis following keywords green supply chain management, productive chain, sustainable product and product green in the Brazilian CAPES database obtaining 2052 articles. Based on data inclusion and exclusion criteria 30 articles were selected as most important to perform the content analysis. It has become clear is that the management of the productive chain and its sustainable operations constitute a challenge for companies that seek and develop their interorganizational competencies and for all the actors involved in the chain. In general, the study points out that the challenges of management professionals are still associated with the incorporation of sustainability in their manufacturing processes. On the other hand, it is perceived that literature is rich in management learning associated with sustainability. Thus, the result of this study seems relevant because it is associated with the conceptual systematization that presupposes management guidelines of the product productive chain that incorporates sustainability. Such learning can serve as parameters for the promotion of sustainable development.

**Keywords**
management; productive chain; sustainability; sustainable product; sustainable development.
Happiness Assessment: A Proposal for More Sustainable Universities

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Abstract

A sustainable university pursues academic excellence, as well as incorporating humanistic values into people’s lives, promoting and implementing sustainability practices. In this way, a sustainable university can promote the minimization of negative effects within society, economy and the environment. Student lifestyles, for example, can contribute to a sustainable transition. This paper presents a proposal for a questionnaire to evaluate happiness in sustainable universities. Currently, productivist methods are used to evaluate students within academic systems, not considering aspects of happiness. Happiness is a basic emotion characterized by a positive emotional state, feelings of well-being and pleasure, associated with the perception of success and the coherent and lucid understanding of the world. Safeguarding the environment towards sustainability is a concept intrinsically linked to the concept of happiness. However, there is still no agreement as to how happiness can be measured. Several are the questionnaires in the literature that evaluate happiness, but none specifically in universities. Three questionnaires were identified and adapted to assess happiness at universities such as Gallup World Poll, Santa Monica Wellbeing Survey and the Gross National Happiness Index Survey - Happiness Alliance. The questionnaire proposed has nine questions or variables: satisfaction with life, safety, recreational activity, social support, relationship, volunteering, desire for continuity, professional future and vision of the future. Every three variables represent a dimension, respectively: well-being, community and perspective. The student is considered happy if attended to seven variables, otherwise not yet happy. The happiness of a group of students can also be measured. This is one way to focus efforts on decision-making by university managers.

Keywords

Sustainable Universities; Happiness; Questionnaire.

Evaluation of the Ecological Footprint in a low-income community of the city of São Paulo Brazil

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Abstract

The Ecological Footprint is an environmental accounting methodology that evaluates the relationship between human population consumption and the capacity to renew natural resources. It is also possible to estimate the areas of consumption that an individual uses to live, feed, move around, dress and consumer goods. This study evaluates a low-income population in a favela in the city of São Paulo, Brazil. According to the Brazilian Institute of Geography and Statistics - IBGE, there are only 1654 favelas in the Brazilian capital, and in Brazil approximately 6% of the population lives in favelas. These homes are seen as one of the most serious social problems in the city and it is a challenge for the public authorities. In the neighborhood of these sub-yards, there is a shortage of public services, such as lack of health, education, culture, leisure, transportation and security equipment. In addition, in these places there are high crime rates as well as activities related to drug trafficking. The research subjects are the residents of the favela Felicidade, located in the São Luís neighborhood, south of São Paulo. According to the 2010 IBGE Census, there are 784 families living in the favela Felicidade. The sample was calculated with a confidence level of 95%, with 197 families interviewed. The approach for data collection was in the interviewees’ residence. The instrument was constructed with questions from the Global Footprint Network Calculator, combined with demographic data from Critério Brasil. Thus, the sample units were classified as belonging to one of the following social classes A, B, C, D, and E. A correlation was made between the main demographic characteristics of the study population and the Ecological Footprint. The results indicate that lower socioeconomic class consumes more food. With respect to consumption in housing and government, no differences were found between these socioeconomic classes. The regenerative capacity of the planet per person, calculated for the whole community, was 1.6 planets, or less than that reported for the capital of São Paulo 2.5 planets, according to WWF Brazil. Among the socioeconomic classes with the greatest 1.6 planets footprint is the B; however, socioeconomic classes C, D, and E showed similar footprints, that is, 1.58. It is noted that in all socioeconomic classes there are families that need a number of more than one planet to live on which could be indicating that more than income other factors such as culture, consumption habits among others could be influencing.

Taking gender into account, there are female family heads with a larger footprint than men. This result was expected, considering that most heads of households are women and are responsible for the family’s livelihood. Regarding age, heads of families over 55 years old were the largest footprint (1.7), followed by the youngest (1.6) and the lowest among the age.
group between 35 and 45 years old (1.4). The results indicate that, with the aging of society, the Ecological Footprint can also increase. Based on the criterion that the higher the level of education, the more one becomes aware of and aware of the natural disasters that are happening, it would be natural to expect more educated individuals to act to alleviate this situation. However, it is noted that in the community the greatest footprint is the heads of families with a higher degree. There seems to be no awareness or basic knowledge to minimize environmental impacts. This result could be indicating the lack of awareness programs and environmental programs in public education. Research shows that consumption is one of the main causes of global environmental degradation. Consumption, therefore, has attracted greater recognition as an environmental problem in academic and political circles. However, most empirical research has focused on consumption, such as impacts, regardless of the social well-being that consumption can generate, to achieve levels of well-being, people may be running out of resources from the earth. The results pointed out in the study can be considered a tool to analyze the sustainability of human activities regarding environmental problems, providing a great help in the decision making processes.

Keywords
Ecological Footprint; Favelas; Consumption.

Sustainability of water and wastewater production systems in Brazil
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Abstract
Despite water treatment being a primary need activity in modern society, it is estimated that 768 million people still have no access to safe water sources for consumption. It is estimated that in 2050 the global demand for clean water will increase by 53% according to United Nation’s data (UN Water, 2014). Still according to UN, the daily drinking water requirement per person is 2 to 4 liters, but still 2,000 to 5,000 liters of water, are necessary to produce one person’s daily food, which represents an indirect consumption of treated water or manipulated water. Water and wastewater treatment activities should be regarded as any other industrial activity. To obtain the final product, water suitable for consumption, are required renewable and non-renewable resources as well as the construction of a production plant which, in turn, will generate residues to be disposed in the biosphere. Several indicators can be used to assess the sustainability of water and wastewater treatment systems. These indicators can be physic-chemical, economic, environmental and social. In this way, the study of sustainability of this production system is a clear multicriteria decision making case study. In this way, the decision makers must be supported by scientific multi-dimension models to justify their choices. To have a powerful and comprehensive sustainability assessment it is necessary to think that the water and wastewater treatment plant plays a role in the larger system, that involves society and environment, where both can be seen as either providers or receivers when relating to the it.

This paper applies the FIVE SEctor SUstainability Model (5 SEnSU Model) (Giannetti et al., 2019) to the assessment of the twenty biggest water and wastewater treatment companies of Brazil. The 5 SEnSU Model presents a methodological improvement considers a holistic approach in the evaluation of sustainability in relation to what is commonly used in the assessment of water and waste water treatment systems. The application of the model will generate a ranking of sustainability of the companies taking into account environmental, social and economic indicators giving a more holistic and embracing characteristics to the sustainability assessment.

Keywords
sustainability assessment; water; wastewater;

Emergy synthesis of the lambari aquaculture in Brazil
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Abstract
Aquaculture is the fastest growing food sector worldwide, achieving an annual production of 110.2 million tonnes in 2016 (FAO, 2018). In Brazil, production achieved 0.6 million tonnes in 2016, mostly based on exotic species (FAO, 2018). From the native species, lambari has attracted attention due to its potential for aquaculture. Lambari is a group of small
freshwater fish widely distributed in Brazil. Its production has recently increased due to the market demand for live baits for sport fishing. As a native low-trophic level specie with a short production cycle and high market acceptance, there is a prospect for lambari to be produced in a sustainable way and to promote sustainable development for rural communities in Brazil. Nevertheless, lambari production is in its early stages, and some inadequate management practices can negatively impact productivity and its sustainability. Thus, the identification and measurement of the system’s weakens and strengths are necessary steps for improving its sustainability.

A total of nine lambari semi-intensive farms located in São Paulo State, Brazil, are considered in this study. They were clustered in three systems (low production control “LC”, medium production control “MC” and high production control “HC”) according to the management strategies adopted, such as feedings production, stocking density, feeding regime, water quality monitoring, mortality rate and productivity. Several metrics have been used to access aquaculture sustainability, such as life cycle assessment (Avadi et al., 2018), indicators of sustainability to aquaculture (Valentí et. al., 2018) and energy synthesis (Odum, 2000). Each metric reflects different aspects of the system under investigation. Since energy synthesis provides a biophysical approach to assess the nature’s contribution in a production system with a “donor side” point of view, it is here used to assess the sustainability of lambari production systems.

Energy, with m, is all the available energy directly and indirectly used to generate a product or service (Odum, 1966). As a first and important step in the energy synthesis, an energy diagram of the evaluated systems was set in order to define the system’s boundaries and elucidate the main inputs, outputs and processes. The main inflows were then computed in an energy table, in which the quantitative values of mass and energy are multiplied by their respective unit energy values (UEVs) resulting in flows of a same unity: solar entoujours (sej). All UEVs used in this work correspond to the global baseline of 1.22E+12 (Brown et al., 2016). Labor and services were accounted according to the standardization procedure proposed by Ulgiati & Brown (2012). Finally, the energy synthesis indices were calculated for each evaluated lambari production system: energy yield ratio (EYR), energy investment ratio (EIR), environmental loading ratio (ELR), renewable (%) energy sustainability index (ESI) and unit energy value (UEV).

Comparatively, results show that the systems have similar energy performance: (a) high dependence on economic resources (EYR of 1.04 and 1.05, EIR > 20); (b) moderate environmental loading ratio with ELR from 7.1 to 9.6; (c) low renewability with %R from 9 to 12%; (d) unhealthy sustainability with ESI of 0.11 and 0.15. The main inflow of LC system is service (43%) followed by feed (28%), while for MC and HC, the main flows are feed (30% and 42%, respectively) and services (16%). The energy demanded by systems was 8.6, 16.1 and 22.5 E16 sej/ha/yr for LC, MC and HC respectively. Regarding UEVs, the MC system showed higher efficiency (1.18 E+06 sej/J) than LC (2.58 E+06 and HCS 2.32 E+06 sej/J) in converting resources into products.

In general, the evaluated lambari aquaculture systems showed low performance in all energy indices, regardless of the management practices adopted; slightly better performance can be observed by the LC system for %R and ELR, indicating that this system uses lower amount of non-renewable resources from economy than MC and HC. All systems are highly dependent on external inputs, mainly commercial feed, considered a resource with low renewability that causes a load on natural environment. Commercial feed is the main input in several semi-intensive and intensive aquaculture systems and its issues, regards to fishmeal consumption, low conversion rate, and wastes generation are well known (David et. al, 2018; Wilfart et. al., 2019; Zhang et al., 2011). Nevertheless, the improvement of natural feed use is a feasible alternative to reduce commercial feed consumption while maintaining productivity (David et. al, 2018), which could also result in better energy indices.

According to our literature review, the energy indicators obtained in this study are similar to other semi-intensive aquaculture systems located in different regions worldwide (Wilfart et. al, 2019; Lima et. al, 2012; Li et. al, 2011). Aquaculture in Brazil is in its initial stages, which claims for efforts in understanding how these systems works with their surround environment and the main drivers supporting their production to propose alternatives towards more sustainable production systems. For instance, the use of local renewable resources such as natural food is an important practice that deserves to be assessed under the same method as used in this work.

Keywords
sustainability; energy; natural resources; fish production

The use of MSW for composites’ production for building fencing panels’ manufacture at Curitiba-Brazil

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Abstract
Based on the need to adapt civil construction procedures to the precepts of the ONU’s 2030 agenda, this study had as objective to develop composites with the purpose of being used for the construction of building fencing panels. Considering Brazil as one of the countries that generates large quantities of MSW - Municipal Solid Waste and generates high waste rates in the civil construction processes, solutions are sought for the use of MSW as proposals of new composites that are produced from such waste. Staying in the SDG - Sustainable Development Goals: "GOAL 11: SUSTAINABLE CITIES
AND COMMUNITIES - There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation and more; GOAL 12: RESPONSIBLE PRODUCTION AND CONSUMPTION - Responsible Production and Consumption were considered discarded materials with no commercial or recycling value, easy access and compatible with traditional building construction material.

During the material’s development, the focus was on the use of discarded materials mainly from MSW. For this, an agreement was signed between UFPR - Federal University of Paraná and a local MSW separation cooperative, and two material types stood out during the waste’s separation: paper, cardboard and EPS - Expanded Polystyrene. In this study, the presentation of a new composite and tests performed through experiments and laboratory evaluations, was considered based on a standard composition and two types of cementitious mortar. One, enriched with cellulose fibers; the other, with addition of EPS from waste disposal household. The alternatives developed were tested considering the Brazil’s technical norms in order to verify the new composite’s characteristics to meet the purpose proposed in this study.

The experiment had as preliminary step the preparation of prismatic specimens for the verification of mechanical characteristics, NBR13279/05, water absorption by capillarity, NBR13779/12, ultrasonic propagation and testimony for SEM - Scanning Electron Microscope. The research’s steps were developed from the formulation and preparation of composites with different traces, and a standard trace of cement, sand and water, in the proportion of 1: 3, was defined, with the ratio (water / cement) A/C fixed at 0,5. The proportions of the addition materials relative to the Portland cement were given from 0.05 cellulose fibers varying in increasing scale until reaching the ratio of 0.2. For the composite with addition of EPS, the proportion was from 0.02 EPS in pellets, with increasing variation until reaching 0.04 of addition material.

The tests’ partial results already reached for mechanical resistance, absorption by capillarity and electron microscopy have led to the conclusion that there is feasibility for the use of materials chosen research’s development. Considering the resistances, with the ages of 14 and 28 days, it was possible to notice that the average of the results achieved were close to the reference values established by the standard trait. With this procedure, it was possible to verify that, for the proportion of 0.1 cellulose fibers in relation to the amount of mixture’s cement, there was a significant decay of the compressive strength, leading to the conclusion that fiber addition values above this, limits the quality of the new composite. For the composite based on EPS addition, preliminary results indicated that the composition in which the material was added, considering the presence of sand, performed better than that in which the presence of this material was eliminated. The results of the capillary water absorption tests were determined by the adaptation of NBR13779 / 12. Thus, the verification had reading intervals for the determination of specimens’ mass, 30 minutes after the specimens were placed in the test cell, 1, 2, 3, 6, 24, 36, 48 and 72 hours counted from the placement of these in contact with water. After the mass check in the 72 hours interval, each specimen was ruptured to analyze the water absorption from the inside. After that, dry band measurements inside the specimens were verified with the use of a digital caliper. Measurements were taken at the ends and at the center of the body proof’s cross section. The average values of the readings indicated that the composite having the addition of cellulose fibers had a capillary water absorption index (C) suitable to make constructive elements for civil construction fence.

As a result, it is expected that innovative products will be developed, in which domestic dry waste and disposal materials are used as feedstock to produce building sealing panels. The research is underway, and it is intended, after verifying the results testing new specimens for composite’s performance evaluation in construction system’s elements.

Keywords
Sustainable buildings; waste’s materials; materials’ performance; new composites; building fencing panels, Brazil.

Chemical Reactions and Behavior of Plastic Residues for Makers Decisions in Cleaner Production

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Abstract

Marine litter has been identified as one of the main threats for the environment. Consequently, need protect all resource base on which marine-related economic and many social activities depend, including the provision that no damage should be caused by marine litter. Plastics account for the largest share of marine litter. The key characteristics that make these plastic materials so valuable in the first place, such as stability and persistency, become the very reason that products made from these materials pose a significant problem for the environment at the end of their life cycle, unless they receive appropriate waste management treatment. When ending up in the seas or washed ashore, plastics turn into a threat to animals and other living organisms, especially due to ingestion or entanglement. Marine debris originates from a variety of sources. Shipping and fishing activities are the predominant sea-based sources, whereas ineffectively managed landfills, public littering, and the careless disposal of residues in the environment are the main land-based sources of marine litter. If plastic residue is deposited in open landfills, lightweight materials, and this especially accounts for plastics, can be blown away by wind or washed away by rain, besides can contaminate the soil with heavy metal, organic compounds, nano- and microplastics. This results in plastic residues ending up in rivers, lakes, oceans, soil and atmospheric air. In order to minimize and prevent pollution of the environment compartments by plastic residue post use, this study presents an environmental impact assessment for plastic residue, based on cleaner production.

Keywords
plastic residue, cycle life of plastic, environmental impact, behavior, chemical pollutant.
Building Energy retrofitting using green construction systems

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Abstract

In many countries the energy consumption of buildings corresponds to around 40% of the total energy demand and in particular the need for heating and cooling of a building represents about 60% of the total energy consumption. For this reason, many authors believe that a shrewd design of the building envelope components is the key to reducing the aforementioned consumption. This point of view is correct in the design of a new building but above all when an intervention must be carried out on an existing building. These buildings, in fact, compared to the previous ones usually consume more energy, if only for the fact that they were built in previous years or decades, often in the absence of regulations governing design criteria for building an energy-efficient building. Furthermore, some authors therefore many authors concentrate their research activities on this particular field of study, focusing on different points of view. Vakiloroaya et al. and Minh Thu et al. analyze the effects of the modernization of the air conditioning system, on Nan Chen, et al., (2011) and Ye et al., (2013) of the lighting system. On the contrary, other authors focus on the results deriving from specific actions on walls. Some authors differentiate the results concerning residential building from those with different intended use, such as offices and industrial buildings. Regarding the latter, it is important not to underestimate the efficiency of the “building envelope-technical installations” system.

It is no coincidence that according to the “Roadmap for research and innovation” drawn up by the “Italian Cluster of Intelligent Factories”, the Italian manufacturing sector will have to face several research and innovation challenges in the coming years, first of all the one relating to the strategies, methods and tools for industrial sustainability. In particular, it is a matter of supporting the development of solutions able to reduce energy consumption of existing industrial buildings through the retrofit intervention economically sustainable.

The research that the authors intend to illustrate in this paper fits exactly in this field of research, in fact it aims to propose a retrofit methodology that will allow to redevelop the façade systems through the use of green construction solutions. The methodological path is composed of three main phases, namely the cognitive phase of energy auditing and building simulation, the meta-design and the design phase and the measurement and verification phase. Below are the details:

- The cognitive phase will be dedicated at the study and analysis of the object of interest, therefore, besides the classification, the solar analysis will be carried out, through the use of the Ecotect software; heat-flux analysis in order to know the values of resistance and thermal transmittance of the main components of the building envelope; thermographic analysis; global consumption analysis using DesignBuilder software. The building simulation is also useful to know the peak values and load profiles of heating/cooling loads of buildings;

- The meta-design phase consists in the identification of the critical and potential aspects of the factory, both established thanks to the in-depth analysis referred to in the previous phase. It also consists in determining the specific objectives and strategies to achieve them according to a certain number of scenarios;

- the last phase is the design phase, developed following the two previous phases. Once the design choices have been defined, the global analysis of consumption in the post-intervention status, the cost-benefit evaluation are drawn up and the guidelines for care and maintenance of the new façade system are defined.

The illustrated methodology has been applied to an industrial warehouse located in Castelnuovo Vomano, Teramo, Italy, intended for the production, sale and display of furniture, light walls, partitions, doors, seats... This building consists of two blocks of rectangular base connected by a common atrium and internally organized so as to accommodate different functions. The energy audit has highlighted important problems in the building envelope, burdened by numerous thermal bridges and thermal transmittance values (U = W/m²K) that do not comply with those established by Legislative Decree 312.2006 for the area where the building is located. Regarding the consumption, the global analysis has shown that the complex needs 111,381 kWh of electricity and 35,290 kWh of gas annually, with a CO2 production of 77,553 kg. The retrofit intervention has been conceived with the desire to compare two different scenarios. In the first one, solutions for energy improvement of the façade system have been used using the traditional thermal coat. In the second scenario, a construction system has been used that integrates a green façade made up of dry-mounted modular panels and a double glazed leather system, protected with oriental sun-blinds. An assessment of the two scenarios has shown that the first one involves a reduction in annual heating and cooling consumption of 11% and 16%, and of 10% of CO2. On the contrary, the second scenario involves a decrease of 18%, 37% and 16% of CO2.

Finally, a cost analysis has been performed on both scenarios which has shown that the pay back time of the second scenario justifies a greater economic commitment of the investment. The illustrated research has highlighted that green construction systems are suitable for implementing energy retrofit interventions, sustainable both from an economic, environmental and social point of view. Furthermore, the proposed methodology could be used to optimize the existing factories retrofit process for better energy performance.

Keywords

Retrofit, green construction systems, energy
Environmental Sustainability in Prioritization of Bridge Maintenance: an Application of Hierarchical Analysis

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Abstract

Bridge maintenance has become an important social and economic concern as these structures must be maintained within acceptable limits of safety and serviceability. Bridge intervention activities are usually very expensive and involve large investments that are not always available to transportation departments, which requires a structured decision-making process from these departments to select and prioritize projects to implement the actions that are necessary to conserving such structures (Abu Dabous and Alkass, 2010).

According to Rashidi et al. (2016), the usual prioritization of bridging repairs is due to the "rule" of selecting those that are in the worst conditions. However, the authors emphasize that this rule does not maximize benefits or reduce the cost of the life cycle, and that the prioritization techniques for choosing bridges for intervention range from subjective decisions based on engineering analysis to complex optimization techniques.

The Analytic Hierarchy Process (AHP), developed by Saaty (1990), can be evaluated as a proposal for a tool for decision support in bridge maintenance. The method is based on the decomposition of the problem into a hierarchy of criteria and then on a pairwise comparison of criteria and alternatives, according to a certain numerical scale. In this work, for the evaluation of this method, environmental sustainability criteria are used in the hierarchization of five different bridges in Brazil. Search not only to meet the minimum levels of service established for bridges, but also to assess the current needs of society and promote an alternative to support sustainable development.

Thus the main objective of the article was the development of a decision-making approach, based on priority level, to assist in the selection of bridges for intervention, seeking to reduce the environmental impact generated by such structures and, at the same time, ensure their maintenance in a timely manner.

In order to evaluate the environmental criteria, the following were considered: "proximity to environmental preservation area", "CO₂ emissions" and "need for resource extraction" to maintain the bridge.

To evaluate the "proximity to environmental preservation area", the distance from the bridge to the closest preservation area was used, considering that the smaller the distance, the greater the vulnerability of the preservation area.

The "CO₂ Emissions" involve two factors: the increase of distance from alternative routes in the case of a bridge interdiction, and the pavement conditions. According to Lounis (2005), if the bridge is interdicted, users will have immediate economic impacts, leading to higher travel costs due to increased travel time, higher fuel consumption, longer lost time and higher vehicle maintenance costs. The author also highlights the possibility of greater environmental impacts due to increased fuel consumption and emissions of polluting gases. A study carried out by ESALQ-USP (2006) points out that, on routes classified as "in poor conditions", there is an average waste of 5.0% of fuel in cargo vehicles. To establish evaluations of the bridges according to this sub-criterion, the frequency of heavy loads can be considered (considering that the weight of the loads transported has an impact on the asphalt, the greater and more frequent the weight, the greater the need for maintenance of the pavement) and the volume of traffic on the bridge (as it indirectly provides a classification of the importance of the bridge in relation to the service provided to users and socioeconomic activity - Lounis, 2005).

For the analysis of the "Need for extraction of mineral resources" were considered scores regarding the level of use of mineral resources in each type of corrective action classification, according to the Technical Note of the bridge, classification of the National Department of Transport Infrastructure (DNIT) 010/2004- PRO (Brasil, 2004). In this classification, each element of the bridge receives a note, which varies from 1 to 5, according to its conditions, with note 1 assigned to a critical work and 5 to a work without problems. The final note of the bridge, the Technical Note, is the smallest of the notes received by its elements with structural function.

The comparison matrices for the different levels of hierarchy were elaborated to evaluate the relative weights of the criteria in each level. The priority of each bridge is calculated by the sum of the product of the weight of the criterion by the respective evaluation of the bridge according to each of the criteria. The evaluation of the criteria is complemented with the verification of the consistency of the judgments. Evaluations of the criteria and alternatives may be performed based on the observation of the bridge inspector and the results of the field and laboratory tests. The results of the proposed prioritization were compared to those of a strictly technical prioritization.

The level of priority of maintenance bridges helps the bridge engineer or decision maker to select the most appropriate bridge for maintenance measures in accordance with established criteria, considering environmental sustainability. Thus, the method provides an important tool for engineers and transportation departments to make decisions and also facilitate the proper allocation of financial resources.

When it comes to sustainability, the transparency of the procedure adopted is a requirement, and therefore a complete ranking of alternatives is a decision support rather than alternatives grouped at the same level. The AHP method provides
a clear understanding of the comparison between criteria, allowing an easy interpretation of the results. The decision maker can easily determine how the final classification changes when different decisions about different parameters are made. The use of the AHP to define the preferred values of the criteria allows to reliably define the relative importance of different criteria in the hierarchy of values underlying sustainability.

The proposed evaluation method can be adopted by decision-makers to prioritize bridges, aiming to adequately provide maintenance for these structures in a timely manner, and prioritize funding, which can also help reduce the chances of a catastrophic failure once maintenance can be carried out on a priority basis.

**Keywords**
Bridge Maintenance; Bridge prioritization; Environmental Sustainability; Decision-making; Analytic Hierarchy Process.

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**An MCDM approach applied to the photovoltaic system selection based on multiple information from environmental and user features**

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**Abstract**

The solar energy micro-generation has grown in the last 10 years according to the database of the U.S. Energy Information Administration (2019) and Global Renewable Energy consumption (2018). It occurs due to the technological efficiency improvements and gradual reduction of equipment costs. However, despite the reduction in costs of Photovoltaics (PV) systems, they have not reached levels to make this type of technology accessible to all. Additionally, there are limitations with the low energy conversion efficiency and the uncertainty of the electric power generation, due to the great impact of the modules when they are partially or totally shaded.

Together with the technological limitations, it was identified the total lack of nominal power of the system, since the photovoltaic system selection requires multiple information from environmental conditions and user features, which they must take in account in the same time. Solar irradiation, although it exists in all places of the planet, has particularities that vary according to the geography of the planet, such as the average amount of irradiation that reaches the soil during the period of one year, cloudiness index, temperature, and others. Additionally to the environmental conditions, it is necessary to take in account the user conditions such as electricity consumption, peak power consumption, the variability of roofs (tiles, fasteners, angle of inclination, etc.). These particularities impact in the photovoltaic system that produces a different electricity average annual quantity for the same kit installed in different locations.

Based on this context, this paper proposes a Multiple-Criteria Decision Making (MCDM) approach to the selection of the most appropriate photovoltaic system considering environmental and user features that could interfere in the power generation. The photovoltaic system selection should be equivalent to the demand of the user, avoiding capital wastage with super generation and preventing the payment of extra tax of electricity power. This research contributes to avoid wasting capital with over installed power; to reduce spending on electric bills; to preserve the environment; to encourage the use of alternative energy sources; to minimize the energy crisis. The approach proposed was validated through multiple experimental cases in the Brazil South region and Brazil northeast region. The results presented the potential of the improvement in the photovoltaic system selection becoming the process more accurate and efficient, considering multiple criteria simultaneously.

**Keywords**
Photovoltaic Systems; Power Efficiency Improvement; Multiple-Criteria Decision Making; Photovoltaic Components Selection Optimization.

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**Life cycle assessment of building materials: a case study of a Brazilian low-income house using conventional and prefabricated construction systems**

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**Abstract**

Civil construction is among the main sectors responsible for the greatest environmental impacts in the world, partly due to the cement industry. As alternatives to the construction system in conventional masonry (CM), composed of reinforced concrete and ceramic bricks and consumes large quantities of cement, there are prefabricated systems such as light wood framing (LWF) and light steel framing (LSF). A gap was found in the literature comparing between these widely applied constructive systems. In this context, this study aims to simulate and compare the environmental impacts of a low-income house in the Brazilian context throughout its life cycle using CM, LWF and LSF building systems. The product system presents a cradle-to-gate LCA: extraction of raw materials, manufacturing materials, transport, manufacture and house
construction; transport and replacement of materials in use; recycling and final disposal. Analysis were carried out in Simapro 9 software using Ecoinvent 3 database and IMPACT 2002+ method. For more precise results, inventory was adapted from world average to the Brazilian electricity matrix. Results were evaluated according to: i) the life cycle phases; ii) the construction materials used in the pre-operation; iii) the construction stages (substructure, superstructure, walls and roofing); iv) the comparison between the three construction systems and v) the comparison between the adapted and the original base data. In the three construction systems, pre-operation was responsible for the greatest impacts, followed by operation and post-operation. Regarding pre-operation, in the CM the average contribution of the superstructure accounted for one third of the total impact. Regarding materials, ceramic brick, Portland cement, ceramic tile and formwork wood were highlighted. In the LWF, the construction stage that contributed the most was the walls with 31.4%. Steel, ceramic tile, structural wood and OSB presented the highest average values of impact. In the LSF, the superstructure corresponded to 40.8% of the impacts of the construction stages. Steel and OSB together represented 51.1% of the total impacts of the materials used in the pre-operational phase. Comparing the three construction systems, taking into consideration all the impacts during life cycle, the CM represented 36.7% of the impacts, followed by the LSF with 31.8% and the LWF with 31.4%. Comparing the generic and the adapted database, results show that Brazilian electricity matrix is cleaner than the world average. Conclusions of this work contribute to the growing LCA literature on construction and decision making about more environmentally sustainable building materials and systems.

Keywords
Life cycle assessment, Conventional masonry, Light wood framing, Light steel framing, Environmental impacts

Chemical Footprint of dioxins and furans in Brazil: Costs and vulnerability for human population

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Abstract
Hazardous chemical substances are found in almost all environments, and humans are constantly exposed to breathing polluted air or ingesting contaminated food and water. The harm to be caused to human health by a chemical will be dependent on its physical-chemical and toxic properties, environmental concentration and distribution among different environmental compartments (Hester and Harrison, 2006). The hazard of a substance is represented by its potential to cause damage. The risk, on the other hand, is the extent of the damage associated with the hazard, that is, estimates the likelihood of the damage occurring under certain circumstances. Among the tools available for environmental accounting, the Chemical Footprint (ChF) was chosen to express the potential impacts to human health of Dioxins and Furans in Brazil. According to Panko and Hitchcock (2011), the ChF is an indication of the potential risk posed by a product based on its chemical composition, the human and ecological hazard properties of the ingredients, and the exposure potential of the ingredients during its life cycle. There is no consensus so far, about the definition of ChF, opinions differ mainly regarding the inclusion of human health impacts and the comparison of carrying capacity or planet boundaries. Scientists agree that the ChF describes the potential impacts of hazardous chemicals on products, organizations or nations (Sala and Goralczyk, 2013, Bjorn et al., 2014, Zipf et al., 2014). We consider the ChF to be an useful tool to measure the potential impacts of human activities on biosphere. The aim of this paper is to estimate the ChF of Dioxins and Furans in Brazil, to account for its costs and to compare the vulnerability of the population of the different Brazilian states.

The Brazilian emissions inventory and the USEtox risk assessment model are used to calculate the ChF of Dioxins and Furans in Brazil. The framework proposed by Sala and Goralczyk (2013), was applied, considering Brazil and its 27 Federative Units (UFs) as system boundaries. The main steps of the research, are shown below:
(1) The source of information on the masses of substances released in each environment (air, water and soil) is the Brazilian Inventory of the Ministry of the Environment (MMA, 2013); (2) ChF was defined as the potential impact on human health, considered equals regarding the Endpoint Impact Score, calculated throughout toxicological characterization (CF) factors of the USEtox model expressed in DALY/year. (3) The federative units (UF) of Brazil were compared based on the ChF of its emission sources. (4) The assessment of the costs of externalities was based on the application of monetary valuation to the DALY to estimate the external costs related to the burden of diseases associated with Dioxins and Furans emissions. (5) The environmental vulnerability of the UF was assessed using a three-phase diagram correlating the potential damage intensity (ChF/tab) x potential dilution capacity (ChF/area) x potential health capacity (ChF/GDP health).

Most of the emissions of Dioxins and Furans in Brazil occurs in 8 federal units (SP, MG, RJ, ES, PA, PR, MA and BA) and considering 2008 emissions amounts, the estimated ChF for Brazil is 620 DALY. The main emission source is ferrous and non-ferrous metal production, contributing 45% to the ChF of Dioxins and Furans in Brazil. This category is subdivided into 12 activities and the most relevant is the Sinterization of iron ore. The second major contributor is Outdoor burning with 30% of the ChF of Dioxins and Furans, this source includes forest fires, mainly occurring in the north and northeast and burning of sugarcane, concentrated in the state of São Paulo and the northeast region. Considering the occurrence of
premature diseases and deaths, the ChF per capita calculated for Brazil is 3.4 DALY per million inhabitants, based on the division of 620 DALY by the Brazilian population. The calculation of social costs related, or externalities were based on the monetary value of one year of life. In Brazil, the estimated social cost of health impacts due to exposure of the population to Dioxins and Furans is approximately US$ 30 million, considering the ChF=620 DALY and the valuation factor of 48,716 US$/DALY as proposed by Desguies (2011). If successfully implemented, the Brazilian National Implementation Plan (NIP) would reduce 592 DALY which corresponds to a benefit of US$ 12 million. The comparison of the vulnerability in Brazilian UF, based on the 3 indicators presented in the 3-axis diagram, shows that most of the Brazilian population lives in 6 UFs classified as Vulnerably critical where the three indicators are below Brazilian median.

The ChF presents itself as an adequate tool to indicate impacts to human health. Chemical risk assessments add more precision to results when compared to assessments based only on the quantities of substances emitted. When associated with monetary valuation, produces results applicable to several research areas. Results on risk quantification the quantification reinforce the conclusions presented on the National Inventory of Sources of Dioxins and Furans (MMA, 2013) stressing the importance of prioritizing these sources as described in the Dioxins and Furans Reduction Action Plan of the Brazilian Ministry of the Environment and in the National Implementation Plan (Ministry of the environment, 2012, 2015b). The environmental vulnerability assessment identified states in which the population is most likely to be exposed to Dioxins and Furans. This result represents a possibility of ordering by importance emission source categories supporting decision making related to public policies in the health and environment sector, as well as the implementation of actions related to the Stockholm Convention.

Keywords
Chemical Pollution. USEtox Modelling. Human Toxicity. Monetary Valuation.

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Compiling and applying multiregional input-output table of urban agglomeration for energy-water nexus

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Abstract
The nexus of energy and water is an important concept for advancing sustainability issues, especially in urban agglomerations with complex interactions between energy and materials. We proposed a novel intercity non-survey method for compiling an urban agglomeration multiregional input-output (MRIO) table which applying to explore the nexus in urban agglomerations. Based on regional employment data, an initial set of regional input coefficients was deduced by the location quotients (LQs). Depended on regional demand and distance, the interregional trade was analyzed by the gravity model (GM). After combining the LQs and GM, the regional trade coefficient was obtained, and the MRIO table of urban agglomeration was subsequently built based on provincial input-output tables. The detailed consumption by water-related energy and water-related water were systematically calculated by MRIO analysis. Then, a multiregional ecological network analysis was further implemented to analyze the energy-water nexus among cities in urban agglomeration. A case study was conducted to demonstrate the scenario of coupled energy and water for the Pearl River Delta (PRD) urban agglomeration. The results show that manufacturing sector played an important role in both energy and water consumption, while agriculture consumed the largest amount of water. The efficiency and redundancy varied among the cities, although the central cities in the urban agglomeration had relatively developed economies and high resource utilization efficiencies, they still consumed large amounts of energy and water. According to the results of resources flow, Shenzhen depended mostly on other cities in the urban agglomeration for both energy and water, and Huizhou was the most self-sufficient city. The recycling rates in energy network were higher than water network in the urban agglomeration. By identifying the characteristics of the energy-water nexus in the PRD urban agglomeration, we provide some suggestions to promote energy and water coordinated management in urban agglomeration, for example, improve vehicle fuel efficiencies, reduce water consumption rates for agriculture, save water for energy production, and optimize the structure of manufacturing.

Keywords
Urban agglomeration; Multiregional input-output table; Energy-water nexus; Pearl River Delta.

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Assessing the resource use by the ornamental plants production systems in Brazil

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Abstract
Brazil is in fifth place in the global flower and ornamental plants production, after India, China, the European Union, the United States and Japan (Abeliotis et al., 2016; Mariotti and Roccatiello, 2015). The cultivation ornamental plants in greenhouses in the country occupies an area of 14,992 hectares divided into about 8,900 producers. The growth of the market for ornamental plants has remained between 6 and 8% between 2016 and 2017, after a considerable growth in the
previous five years. The sector is responsible for more than 190,000 direct jobs, of which almost 50% are related to the production of ornamental plants (IBRAFLOR, 2015). The State of São Paulo, where the cultivation of flowers and ornamental plants has begun in the 1950s, is the largest flower producer in the country, responsible for 70% of the national production (Junqueira and Peetza, 2008). The State accounts for 48% of the Brazilian producers, followed by Minas Gerais with 13%, Rio de Janeiro with 11% and Rio Grande do Sul with 4%. The environmental impacts of the flowers and ornamental plants sector are associated not only with the cultivation (Abelio et al., 2016) but also with the transportation that mainly uses trucks for product distribution. Most of the greenhouses cultivate numerous species, varieties and hybrids with very different demands, but their operations, although contributing to the increase of productivity and the quality of the products (Russo et al., 2008), also contribute to the increase of energy, water, fertilizers and pesticides usage.

This work uses the energy synthesis to evaluate the cultivation of ornamental flowers in greenhouses in the region of Aracaju, State of São Paulo with the objective of assessing the use of resources and quantifying the environmental load of this the productive system. The study will be an important contribution to improving the efficient use of resources in the production of greenhouse flowers and ornamental.

**Keywords**

Greenhouse, ornamental plants, flowers, energy

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**Water Intake and Discharge Impact Analysis and Measures for Water Resources Assessment of Coastal Nuclear Plant Projects in China**

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**Abstract**

Nowadays, cleaner production continues to deep into the hearts of people, and nuclear power generation has been widely used due to its low energy consumption and low pollution. In China, all nuclear power plants including constructed ones and those under construction are coastal ones. Large amount of water used in a nuclear power plant and the high guarantee rate of water use will have a certain impact on the regional water resources allocation in the site area. During the water discharge process, low-level radioactive waste water and warm water will be discharged. Even in the accident, medium or high radioactive wastewater will occur and affect the environment of the receiving water area. Several years ago, Chinese government began to work out the Guidelines for Water Resources Assessment of Coastal Nuclear Power Plant Projects. The research mainly analyzed the impacts of water intake, the impacts of wastewater discharge, their reduction measures, water conservation measures, water protection measures and water management measures, which can give a technical support for formulating the Guidelines for Water Resources Assessment of Coastal Nuclear Power Plant Projects. In this study, the technical requirements for impact analysis of water intake, impact analysis of wastewater discharge and their remedial measures for coastal nuclear power construction projects in different periods were put forward. Finally, the measures for water conservation, protection and management were given.

**Keywords**

coastal nuclear plants; water resources assessment; water intake and discharge impact.

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**Improvement of instantaneous point source model for simulating radionuclide diffusion in oceans under nuclear power plant accidents**

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**Abstract**

Simulation methods have become an important tool to reveal radionuclide migration during accidental radionuclide releases and predict influences of accidents on the marine environment. The instantaneous point source model is a useful method to simulate the large-scale radionuclide diffusion in marine areas. However, the simulation accuracy of this method requires improvement as it didn’t take radionuclide decay into account. In this study, an improved instantaneous point source model considering radionuclide decay was proposed on the basis of the original model. Furthermore, the instantaneous point source model and the improved version were used to simulate the concentrations of 131I and 137Cs following the Fukushima Dai-ichi nuclear power plant accident. The results showed that the relative error of 131I concentrations decreased from 200.07% to 14.12% when using the improved model, and improvements in relative errors for 137Cs concentrations were not apparent as the simulation period was much shorter than its half-life period. Therefore, the improved
model can accurately simulate the diffusion process for radionuclides following an accident and provides an efficient decision support tool for risk assessment managers and for use in safety guarantees of nuclear power plants during siting and operational phases.

**Keywords**

Instantaneous point source model; Radionuclide diffusion; Fukushima Dai-ichi nuclear power plant accident; Decay.

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**Influencing Factors Analysis for Urban Carbon Emission Based on GWR model—Taking Yangtze River Delta Urban Agglomeration as an Example**

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**Abstract**

With the rapid development of China’s economy, people’s demand for energy is increasing, and the emission of greenhouse gases such as carbon dioxide is gradually increasing, especially in the Yangtze River Delta urban agglomeration, one of the six major urban agglomerations in China. The Yangtze River Delta urban agglomeration is surrounded by five major urban agglomerations and five major development zones, and has rich natural landscapes, cultural landscapes and industrial structures. It can reasonably utilize the interconnection of industrial and economic structures between cities, and can effectively control the emission of greenhouse gases such as carbon dioxide, so that economic development can achieve harmony with people at the minimum cost of energy consumption. Taking 26 cities in the Yangtze River Delta urban agglomeration in 2016 as an example, this paper uses STIRPAT to construct a carbon emission influencing factor analysis model, and points out the quantitative relationship between carbon emissions and these influencing factors, and then establishes a geographically weighted regression model based on the STIRTPAT model. The analysis of the carbon emission factors and geographical relationship in the urban agglomerations of the Yangtze River Delta provides the most favorable development model for the low-carbon and efficient development of the Yangtze River Delta urban agglomeration.

**Keywords**

STIRPAT model; GWR model; Carbon Emission; Influencing Factors Analysis.

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**Eco-efficiency assessment and structure optimization of municipal solid waste treatment system for the typical villages and towns in the headwater of Huaihe river basin**

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**Abstract**

As a complicated system concerned with multi-factor including environment, economy and technology, municipal solid waste treatments for villages and towns are different for various geographic areas, due to their unique physicochemical characteristics and distributions. However, at present, it is lack in the study about the method of the performance evaluation, which is still far away from the practical demands in the treatment of municipal solid waste. Therefore, from the perspective of environmental improvement caused by the unit cost increase, this study will propose the ecological efficiency model with the integration of life cycle assessment (LCA) and life cycle cost (LCC). Meanwhile, it also raises a set of structure optimization models based on the equilibrium of environmental and economic impact, with the aid of multi-objective nonlinear programming (MONP) method, this study attempts to explore pareto optimal allocation structure and actual management paths of municipal solid waste treatments for villages and towns. Three towns (including nine villages) in the headwater area of Huaihe river basin will be selected for empirical research, which represent three kinds of geomorphic types respectively, such as plain, hill and low mountainous. Then, this study will analyze the spatial-temporal variation characteristics of composition and physicochemical property of municipal solid waste for this area. Subsequently, parameter data base will be established about environmental impact and economic cost of solid waste treatment. At last, adaptive management patterns are explored considering regional characteristics. This study will provide important scientific supporting data and decision-making tools for the waste management practice in the headwater area of Huaihe river basin.

**Keywords**

village and Towns Municipal Solid Waste Life Cycle Assessment Ecological Efficiency MONP
Water resources force on urbanization and economic growth: A case in China

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Abstract
This paper investigates the causal relationship between water resources consumption, economic growth and urbanization in the case of China, while utilizing the data over the period of 1989–2009. We have applied unit root tests to examine the stationary properties of the series, finding the data series are stationary. Then, We employs the ARDL bounds test to investigate long run relationships. The Granger causality test is subsequently used to examine the direction of causality between water resources consumption, economic growth and urbanization. Our results indicate the existence of long run relationships. It imply that maker of urbanization policy must not only continue to develop economy, but also protect water resources to ensure enough clear water. We further find there are a bidirectional causality between water consumption and economic growth. Feedback hypothesis is observed between water consumption and urbanization, and between economic growth and urbanization. Consequently, the relevant authorities should boost clear water resources as one of the means of achieving sustainable urbanization in the long run.

Keywords
water resources, economic growth, urbanization

Forecasting carbon emission of the industrial sectors in the Pearl River Delta Urban Cluster based on STIRPAT model

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Abstract
With the intensification of global warming and continued growth in energy consumption, China is facing increasing pressure to mitigate carbon emission. In order to support decision making in industrial carbon mitigation, a hybrid method was developed through incorporating logarithmic mean Divisia index (LMDI) and stochastic impacts by regression on population, affluence, and technology (STIRPAT) models into the framework of carbon emission analysis of industrial sectors. The carbon emission peak of industrial sectors was forecasted in this paper when considering the impact of employees’ number, economic growth, energy utilization, policy, technology level and energy consumption structure. Main factors responsible for the industrial carbon emissions were identified by LMDI method. And the contributions to carbon emissions by the key factors were analyzed by STIRPAT model. The developed methods were then demonstrated in the urban cluster of Pearl River Delta, China. Three scenarios were proposed to indicate the uncertainties in industrial carbon mitigation. It was proved that the developed methods were effective in recognizing key factors which influenced industrial carbon emissions and forecasting carbon emissions of industrial sectors in the urban and urban-cluster levels.

Keywords
STIRPAT model; LMDI method; carbon emission; Pearl River Delta Urban Cluster; scenarios analysis

Energy and water use in the U.S. catfish industry

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Abstract
Improving energy and water use efficiency in the seafood supply chain will reduce the environmental burdens and, at the same time, increase food security and benefit the producers’ bottom line. Bearing in mind that the 2015–20 Dietary Guidelines for Americans advise citizens to more than double their average intake of seafood, and the fact that the seafood supply chain wastes 40 to 48% of the edible US seafood supply, investigating energy and water resource use in seafood production is crucial to long-term food security and resilience. To assure the long-term viability of the linked food, energy, and water systems associated with the US seafood supply, there is an urgent need for robust, industry- and consumer-accepted, cost-effective strategies to reduce excessive resource use and waste while retaining the nutritional advantages that seafood offers. As part of a larger study of the US seafood supply chain, this study evaluates, by means of the Life Cycle Assessment, the direct and indirect energy and water consumption related to the U.S. catfish production.

Catfish are fed with a grain-based diet that includes soybean and cottonseed meals with the addition of animal proteins
usually from fish meal and meat and bone meal. The feed composition changes depending on fish age, size, and stage of culture as fry and fingerlings have a higher protein requirement than the adult fishes. The stages of the aquaculture include a hatchery phase to grow up fingerlings that are subsequently sent to a producer phase to final harvest of adult fishes. The production of a food-sized fish (about 0.7 kg) from an egg can last 18 to 36 months. Mature fishes are then processed in the last step of the production chain and transformed to different product forms (fillet, whole head and gilled, nuggets, steak, etc.). So, four steps were identified and analyzed separately: feed preparation, hatchery, producer, and processor phase. Both the feed for fingerlings and adult carps were modeled using data from available ecoinvent processes, primary data from two feed mills, and a USDA report for six different feed formulations. To collect primary data, three hatcheries, five producers, and three processors were visited in Alabama and Mississippi, where, according to the USDA, more than 80% of the total U.S. carpish is produced.

SimaPro software v.9.0 and the ecoinvent database v.2.5 were used to evaluate energy and water use. The ReCiPe 2016 midpoint H impact assessment method was selected to estimate fossil and water depletion, calculated in kg of oil equivalent and m3 of water, respectively. In addition to these impact categories, other sustainability indicators have been considered.

The water consumption and the energy required for feed preparation ranges between 0.08 and 0.18 m3 and 0.12 and 0.2 kg oil eq. per kg of feed, respectively depending on feed end use. To produce 1 kg of fingerlings requires 0.65 kg of oil eq. and 2.15 m3 of water, while the energy depletion associated with 1 kg of carps is equal to 0.35 kg of oil eq. The hatchery phase is the most water intense step of the production chain (1.4–1.8 m3 per kg of produced fingerling). In energy terms, processing the fish in the different product forms is the most intense segment of the entire supply chain. Overall a kg of processed carpish (at the processing plant gate) requires between 4.3 kg of oil eq. and 3.7 m3 of water.

The identification of the most resource-intensive inputs and stages of these of the seafood supply chain, thanks to the Life Cycle Assessment approach, will enhance effectiveness of interventions and policies to reduce or modify seafood resource use towards more efficient and sustainable production patterns.

**Keywords**
Aquaculture, U.S. carpish, Life cycle assessment, Nexus, Food-Energy-Water

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**Human appropriation of net primary production in China and biases in crop production data**

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**Abstract**

Economic and population growth result in increasing use of biophysical resources, including land and biomass, which has caught worries of natural resources sustainability. The human appropriation of net primary production (HANPP) is an integrated sociocological indicator quantifying effects of human-induced changes in productivity and harvest on ecological biomass flows. We present a comprehensive multi-level assessment of HANPP in China based on vegetation modeling, agricultural and forestry statistics, and geographical information systems data. HANPP indicators for 31 provinces for the year 2007, 2010, and 2012, and 350 prefectures for the year 2010 were calculated. Data for 1 km x 1 km grid was mapped based on land cover data for the year 2010. The results show that there is a large spatial heterogeneity in the appropriation of net primary productivity in different provinces and land cover types in China, and the overall appropriation extent is high. The HANPP% in some regions exceeds 100%. On the one hand, it reflects that the demand for natural resources in some areas of China has exerted great pressure on the ecosystem. On the other hand, it may indicate the deviation of statistical data. The method of using NPPharv/NPPact (%) to correct the original statistical data is proposed to acquire more accurate results.

**Keywords**
HANPP, China, Statistical data bias, Sustainable development

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**Emergy-based evaluation sustainability of recycling for wheat-maize straw system in the Northeast plain**

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**Abstract**

Straw, as a by-product of crops production, is also an important resource for human existence and society development. As a big agricultural country, the straw yield of China ranks the first in the world, with an estimated 588 million tons produced in 2014. And the northeast plain is the main agricultural planting area, which the main crops are wheat and maize that generate abundant straw resource in production process. Thus, utilization of straw as energy with high efficiency and rationality not only meets energy demands as economy growth, but also provide a basic for environmental protect and sustainable development. However, although more than of 80% of straw is recycled by various patterns, such as
incineration, raw material for industrial product, fertilizers and so on, the largest challenge we face is that how to increase the utilization rate of straw and transform straw recycling process from more quantity to more efficient. Therefore, it is essential to evaluate the resources consumption and analyze the economic profit in the straw recycling process.

At present, researches on the evaluation of wheat-maize system are mainly concentrated in several aspects, including resources utilization efficiency, material circulation in the recycling system and pollutant emission. Few studies analyze the overall recycling system and evaluate its sustainability. Under this circumstance, this study aims to access the comprehensive utilization condition of straw, system sustainability and economic yield by analyze resources consumption in each division. However, traditional analysis methods, such as energy analysis and material flows method, can only analysis system in single aspect, which cannot evaluate system comprehensively. Nevertheless, the energy analysis method takes into account not only the free environmental flows provided by nature, but also the time needed for resource generation within biosphere processes as well as the economic flows of labor and services, to be considered measures of the societal infrastructures supporting the process.

Under this circumstance, this study aims to use the emergy method to analyze wheat-maize recycling system and evaluate its sustainability by emergy based indicator, presenting feasible advices for system sustainable development.

**Keywords**

Wheat-maize system, Northeast plain, Emergy analysis, Sustainability.

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Developing An Urban Emergy Dynamic Calculator for the Food-Energy-Water-Land-Climate Change (FEWLC) Policy Nexus Effect Assessment

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**Abstract**

As a key approach and sustainable solution to global environmental challenges, nexus has gained more and more attention in recent years. In addition to the nexus between water, food and energy spheres, there are inextricable linkages of land and climate change between these three domains as well, which could lead to different various impacts on the policy-making. Efficient resource management plays an essential role in achieving sustainable development of urban city, which requires to identify the potential synergies or conflicts between the five systems. However, the different impacts caused by the policy nexus between the five systems haven’t been quantified until now. Taking Beijing city as a case, this paper describes the linkages of the policy from a nexus perspective by using real scientific data. What’s more, an emergy dynamic model capable of accurately simulating the environmental impacts caused by the policy nexus will be developed, which is a feasible approach to help the policy-makers create possible pathways under food-energy-water-land-climate change (FEWLC) nexus framework. The model provides quantified analysis for these various policy scenarios. What’s more, long-term simulations will be provided by this model to test the trajectories of policy nexus effects under the assumptions of the associated levels. Therefore, this model can serve to identify urban comprehensive performance under the FEWLC nexus framework, which is beneficial to help target synergies and avoid potential tensions. Finally, some policy-making suggestions based on the simulation result are provided.

**Keywords**

Urban; Energy-water-food-land-climate; Nexus; Policy

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The carbon metabolic analysis of Dongguan City, China

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**Abstract**

Understanding the mechanism of carbon metabolism is crucial for urban sustainable development in the context of global warming. In order to systematically analyze the urban carbon metabolism feature, input-output analysis (IOA) method and ecological network analysis (ENA) method were combined to establish an urban metabolic network model in this paper. Concretely speaking, IOA was introduced to account for the carbon flows of seven urban compartments and analyze the structure of flow distribution from both production-based perspective and consumption-based perspective, and ENA was used to discern the directions and interactions among seven compartments in the ecological metabolic network. Taking Dongguan, a typical city famous as "World Factory", as a case study, the results show that the direct carbon flows in 2012 were mainly concentrated in manufacturing sector from the both perspectives, and the consumption-based carbon flows of electricity, gas & water sector were mainly induced by itself. Additionally, exploitation was the predominant relationship in the urban metabolic ecosystem, and the symbiotic index reflects that Dongguan was a
symbiotic ecosystem. In view of the metabolic characteristics of Dongguan, it is suggested to heighten the energy utilization efficiency of compartments and promote sectoral positive interaction, which could further alleviate disorder and resource waste in cities.

**Keywords**
Input-output analysis; Ecological network analysis; Urban carbon metabolism; Ecological relationships; Dongguan

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**Clean solid biofuel production from high moisture content biomass waste by employing hydrothermal treatment technology**

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**Abstract**
Reducing the dependence on fossil fuel is a common social challenge all over the world. Biomass is unique among renewable energy sources because it can be used to produce solid and liquid fuels with conventional conversion pathways in chemical industries. Wet biomass (organic waste and sewage sludge) is a partially unutilized resource with very low fuel price, if not zero or negative, in the market. However, such biomass is hard to utilize due to high moisture and ash content as well as low density. Hydrothermal treatment technology (HTT) is an efficient pretreatment technology for solid biomass wastes to increase density and heating value and to decrease moisture content which employs saturated steam as a media for the different degrees of hydrolysis as well as mechanical destruction of cell walls. The treatment begins by loading raw material into a reactor, followed by steam injection into the reactor. Mixing is then conducted by a stirrer in the reactor, while maintaining the temperature and pressure.

In this study, HTT processes of typical biomass wastes (municipal solid waste (MSW), sewage sludge (SS), and rice straw (RS)) were carried out for biomass hydrochar preparation using a 3L hydrothermal reactor. MSW was composed of chicken meat, wood waste, bread, cheese, and plastics, which was the common waste components in Japan. Moisture content in MSW, SS, and rice straw were around 20 wt.%, 80 wt.%, 15 wt.%, respectively. Effects of varied holding time (3min, 15min, 30min) and different final temperatures (160 oC, 180 oC, 200 oC, 220 oC, 240 oC) on HTT processes and the corresponding solid fuel characters were compared. MSW The results showed that feedstock type, reactor pressure and holding time at the target temperature are three key factors affecting the solid solubility and dewatering efficiency after HTT process. Solid solubility for all the feedstock increased with HTT pressure and holding time, which was not favorable for realizing high solid fuel yield. The lowest temperature and pressure conditions for the powdered fuel production from MSW and RS were 200 oC and 1.4 MPa, and 220 oC and 1.4 MPa, respectively, while HTT of SS could produce powdered solid even at low temperature and pressure of 160 oC, 0.7 MPa. It is noted that the dewatering efficiency by using vacuum filtration system of SS decreased dramatically with decreasing HTT temperature, and showed worst at 160 oC (240 oC < 220 oC > 200 oC < 180 oC < 160 oC). Moreover, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of waste water after HTT all increased with increasing HTT temperature for all the feedstock, while the liquid PH after the HTT and the reactivity and the lower heating value of solid fuel showed opposite trends. In conclusion, considering the solid fuel characters and HTT process efficiency, the optimal powdered HTT products formed at 200 oC and 1.4 MPa, 180 oC and 1.1 MPa, and 220 oC and 1.4 MPa for MSW, SS, and RS, respectively.

**Keywords**
hydrothermal treatment; biomass wastes; solid fuel

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**Urban comprehensive evaluation and limiting factor analysis: A case study of cities along the Belt and Road**

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**Abstract**
To support the construction of green “Belt and Road”, it is necessary to understand the status of urban development and identify the limiting factors, especially considering the importance of cities for the regional development. Therefore, we firstly established a four-in-one assessment framework, namely structure, function, process and systems, to comprehensively evaluate the urban status by introducing the concept of urban ecosystem health. Secondly, 17 indicators were established to concretely measure the urban ecosystem health state based on energy analysis. Then, the urban ecosystem health levels were calculated and compared by using set pair analysis. By choosing the 14 typical Chinese cities along the Belt and Road
as the case, the results show that the urban ecosystem health levels of different cities showed a gradient trend during 2012–2015. For most of cities, the urban ecosystem health was at a medium level, while Kunming and Changchun had relatively high health level and Shenzhen, Shanghai and Zhengzhou had relatively low health level. In terms of the limiting factors, most of cities with relatively low health level performed poorly in dimension of process and system, while a few cities like Zhengzhou performed weak in all four dimensions. Finally, some suggestions were put forward to improve the urban health states.

Keywords

emergy analysis; ecosystem health; set pair analysis; the Belt and Road; cities

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Research on the spatial network structure of green development in China

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Abstract

It mainly uses the 2016 Green Development Index of 30 provinces in China to construct a modified gravity model, and uses social network analysis methods to explore the spatial network structure characteristics of China’s green development. The study found that: in 2008-2016, China’s green development level has improved significantly, the regional differences are narrowing but the differences are still obvious, and the inter-regional linkages break through the geographical proximity effect, presenting a wide range of complex network associations and structural forms and tending to be stable, Shaanxi and Henan are located in the center of the network due to their geographical location and are located in the center of the network. They can be cultivated as new green development and growth poles; the “two-way overflow” plate mainly based on the Bohai Sea and the eastern coastal areas, mainly for economic development. And technology spillovers, mainly benefiting from the eastern coastal provinces, benefiting from the supply of resources in the northwest and Bohai Rim regions, and the “net spill” sector, which is dominated by the provinces in the northwestern region, mainly supplies resources to the Bohai Rim region. The clustering is obvious, it is necessary to break the administrative barriers, promote the technology and capital flow between the sectors, and achieve coordinated development.

Keywords

green development; spatial network structure; social network analysis; regional coordination

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Strengthened efforts to adequately reduce environmental impacts of food system in China

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Abstract

Sustainably achieving global food demand is one of humanity’s serious challenges, and requires efforts of both producers and consumers. Yet, there is few attempts to illustrate the effectiveness of mitigation strategies at sub-national regions and to identify the interregional linkages along food supply chain. In this research, we built a comprehensive evaluation framework to model the current and future environmental impacts of food system and the mitigation effects of strategies on the supply- and demand-side of food supply chain. We evaluate the mitigation effects of supply- and demand-side strategies, compare the mitigation effectiveness with downscaled Planetary Boundaries at national and provincial levels and redistribute food production by optimization method to keep all provinces around the environmental boundaries. We found that the impacts of phosphorus, nitrogen and water need to reduce more than 70% to meet the national environmental limits. The basic but ambitious strategies can contribute a substantial mitigation, but can hardly to reach the upper boundaries for all the environmental impacts, as nitrogen impact is still larger than the upper boundary. Increasing additional 10% of efficiency and adjust an additional 10% of FLW and diet deviations in the crucial regions with large excessive emissions, nitrogen impact will be slightly lower than the upper limits and stay in the uncertain zone. The phosphorus, nitrogen and water impacts in many provinces are still more than 5 time larger than regional boundary, even the reduction rate for most regions are around 80%. In this case, we propose a redistribution of some food production in those transeussed regions into those with free space to accommodate more food production. We can reduce food production mainly in north china plain regions (Hebei, Henan and Shandong), and increase a same amount of food production and environmental impacts in southeast southwest China (like Guangxi, Guangdong and Sichuan).

Keywords

Food system; Environmental impacts; Mitigation; Planetary boundaries; Redistribution
Virtual scarce water trade and saving within China

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Abstract

Trade of commodities can lead to virtual water flows between trading partners. When commodities flow from regions of highest water productivity to regions of low water productivity, the trade has the potential to generate water saving. However, this accounting of water saving does not account for the water scarcity status in different regions. It could be that the water saving generated from this trade occurs at the expense of the intensified water scarcity in the exporting region, and exerts limited effect on water stress alleviation in importing regions. In this paper, we propose an approach to measure the scarce water saving associated with virtual water trade (measuring in water withdrawal/use). The scarce water is quantified by multiplying the water use in production with the water stress index (WSI). We assessed the scarce water saving/loss through interprovincial trade within China using a multi-region input-output table from 2000. The results show that interprovincial trade resulted in 14.2 km³ of water loss without considering water stress, but only 0.4 km³ scarce water loss using the scarce water concept. Among the 435 total connections of virtual water flows, 254 connections contributed to 20.2 km³ of scarce water saving. Most of these connections are virtual water flows from provinces with lower WSI to that with higher WSI. Conversely, 175 connections contributed to 20.6 km³ of scarce water loss. The virtual water flow connections between Xinjiang and other provinces stood out as the biggest contributors, accounting for 66% of total scarce water loss. The results show the importance of assessing water savings generated from trade with consideration of both water scarcity status and water productivity across regions. Identifying key connections of scarce water saving is useful in guiding interregional economic restructuring towards water stress alleviation, a major goal of China’s sustainable development strategy.

Keywords

virtual water trade virtual scarce water saving input-output analysis

Assessing the impacts of different urban dynamics on urban surface runoff

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Abstract

Along with the rapid global urbanization and climate change, land-use changes associated with the process of urbanization lead to considerable negative environmental consequences, among which the transformation of the hydrological behavior has become a critical issue over the years. The process of urbanization leads to an increasing proportion of impervious surfaces in the urban area, inhibiting interception, infiltration potential and thereby raises the risk of urban flooding. For future urban planning, it is of significant importance to understand the impact of different urban dynamics on urban surface runoff to improve urban resilience to flooding.

Taking the characteristics of different residential types into consideration, the present study aimed to reveal the impacts of different urban dynamics on surface runoff in the city of Munich, southern Germany. The land use and land cover data were digitized from high-resolution aerial images based on visual interpretation. Two residential land use types were distinguished including the low-density settlements and high-density settlements. First, the surface cover characteristics of both residential types were quantified using the ‘i-Tree Canopy’ method. Second, the Soil Conservation Service Curve Number (SCS-CN) method was employed for surface runoff simulation. Last, a scenario-based urban dynamic modeling approach was employed to assess the impacts of different urban dynamics on surface runoff.

The results can be concluded that, first, given the same precipitation depth and hydrologic soil group, low-density settlements tend to generate less surface runoff as they have considerably more vegetative surfaces but less built surfaces than high-density settlements. Second, owing to the fact that the development of low-density settlement leads to more green and open spaces being lost in the surrounding peri-urban areas, more surface runoff would be generated at the city scale under the sprawl growth scenarios which is characterized by the growth of low-density settlements. The findings of this study could deepen our understandings on the relative advantages and disadvantages of different urban dynamics in surface runoff mitigation, which would be helpful in the formulation of future planning strategies.
Keywords
Surface runoff; Urban growth form; i-Tree Canopy; SCS-CN method; Munich city

An improved gray water footprint model to analyze virtual water flow in China
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Abstract
Previous studies had deeply discussed the impact of virtual water flows on alleviating domestic water scarcity and revealed that the volume of virtual water trade have more than doubled over the past two decades. Nevertheless, most of these studies focused on water quantity related with blue and green water footprint, the impact of virtual water flows on water quality related with grey water footprint (GWF) have been largely neglected. A few studies taking GWF into account tackle the problem only partially: the GWF value is totally determined by the highest concentrated pollutant, disregarding the co-presence of compounds. In this study, we incorporate an improved GWF model considering multiple pollutants into virtual flow analysis in China of 2007. We observe that the virtual transfer of water embodied in interprovincial trade accounts for 28.7% of China’s water footprint. The virtual green water, blue water and grey water flows are 165.6 Gm3/y, 155.2 Gm3/y and 687.5 Gm3/y, respectively. Previous studies quantifying virtual water flows based on the indicators related with water quantity will result in underestimating the impact of economic activities on fresh water availability. We identify top sectors in virtual water transfer, including agriculture, chemical industry and petroleum processing, which account for 67.3%, 8.1% and 5.9% of the total virtual water flows, respectively. The developed regions facing water scarcity such as Beijing and Shanghai outsource both quantity- and quality- induced water shortage to undeveloped provinces such as Henan and Hebei. Our study show the need for regions to collaboratively manage water resources as well as control water pollution, and lay the foundation for water scarcity regions to develop strategies to mitigate such risk.

Keywords
Virtual water flows, Grey water footprint, Multiple pollutants, Water scarcity

Environmental Effect of Electric Vehicles Replacing Traditional Ones: Crisis or Opportunity
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Abstract
There has been a substantial boom in China for automobiles, with the civil vehicle ownership/stock increasing from 10.4 million in 1995 to 209.07 million in 2017 (NBS, 2018; NBS, 1999). The dual increase of population and vehicle ownership per household will result in the increase of registered vehicles in China (NBS, 2018), which will cause greater environmental impacts from vehicles. These impacts may be mitigated by the use of alternative fuel vehicles (AFVs) such as battery electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV), as mentioned in some studies such as saving energy (Alirezaei et al., 2016), carbon footprint (Onat et al., 2015), air pollutant emissions (Karaslan et al., 2018). That is why the government in China where is the world’s largest automotive market is determined to develop electric vehicle (EV) industry and produced over 250 thousand EVs in 2015, and the annual growth rate was 420% (CAAM, 2016). However, the mitigation may not so obvious or even opposite if we consider the accumulative environmental effects of the whole lifecycle of AFVs compared to internal combustion engine vehicles (ICEV). The strong focus on energy consumption and CO2 emissions during the use phase when assessing the impact of transportation underestimates the environmental impact of AFVs. It was found that ICEV caused a relatively low environmental impact during raw material extraction, product manufacture, and the disposal stage based on a comparative study of the two prototype vehicles of EV and ICEV (Gradin et al., 2018). In manufacturing phase, compared with ICEV, AFVs demand additional energy and material input, such as the input in battery manufacturing and the construction of charging stations and associated power grid, which surely produced additional environmental impacts. For examples, the energy consumption and greenhouse gas emissions of a battery electric vehicle production range from 92.4 to 94.3 GJ and 84.0 to 52.5 t CO2eq, which are about 50% higher than those of an internal combustion engine vehicle (Qiao et al., 2017). In addition, BEVs may consume up to 70 times more water than ICEVs (Onat et al., 2018). Both examples indicated that the transition from ICEV to AFV undoubtedly demanded more energy and resources and discharged more wastes. 15% of the total environmental impact of E-mobility caused by the battery (Notter et al., 2015), in which

the major contributor is the supply of copper and aluminum for the anode and the cathode, plus the required cables or the battery management system. Moreover, copper was evaluated as one of bottleneck materials for the low-carbon energy transition (Valero et al., 2018). Global copper reserves in 2007 would be depleted within 40 years at the current rate of mine production. Even worse, an expected growth for annual copper demand is a factor 2.6 to 3.5 in 2045–2050 in comparison
to 2010–2015 (Henckens et al., 2014; Elshkaki et al., 2016; Deetman et al., 2018). The cumulative demand of copper would surpass the identified resources before 2100, even with high recovery and recycling rates (Schipper et al., 2018).

In China, copper is the second largest strategic raw material, but its demand-supply gap has enlarged greatly in the last two decades (Zhang et al., 2012). In 2017, the import of copper ore and its concentrate for China was about 9 times of their export from China, and had increased about 18.5 times since 1997, the import of unwrought copper and its alloys was about 12 times of their export and had increased about 19.5 times since 1997 (NBS, 1999; 2018). As the automotive industry continues to electrify its fleets, copper supply gap for China would be enlarged, considering that copper ores are comprising almost 20% and 44% of the total material footprint of vehicle and battery manufacturing, respectively (Sen et al., 2019). The most serious situation could occur in Fujian province where the world’s largest manufacturer (CATL) and main production base of electric vehicle batteries are headquartered and its fleets were electrified rapidly. Unfortunately, little research efforts as of now have been directed specifically toward understanding the fundamental relationship between the electrifying and copper demand.

Thus, this article will develop an integrated model of dynamic material flow analysis combined with autoregressive integrated moving average model for the prediction of passenger vehicle ownership and its EV market share in Fujian. Then due to the change of future passenger vehicle ownership and its EV market share copper demand will be extrapolated from 2017 to 2050 for analyzing the trend and structure of pollutants. Key aspects were then proposed for maintaining the sustainable copper use. Therefore, extrapolating copper demand of regional automobile industry transition would be helpful not only for accurately forecasting regional or global copper utilization trend, but also for strategic planning and sustainable management of environmental impacts of regional and global copper industry.

**Keywords**

Passenger vehicle; Copper demand; Resource demand; Environmental impacts; Fujian

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**Forecasting The Area share and Yield of Maize in Zambia Based on Error Correction Model**

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**Abstract**

In ensuring a cleaner and sustainable agricultural production which increases efficiency in the allocation of resources at the same time decreasing waste, this paper estimates the yield and area share of maize in Zambia using the Error Correction Model. The aim is to offer an empirical approach in conserving land use, energy, water, human capital and eminent resources in agricultural production by assessing the impact of cultivated area share on yield and maize output using error correction model. Zambia is a middle income emerging country located in the Southern Sub-Saharan of Africa. The study focuses on maize, which is the staple food crop and hence a widely grown crop among farmers in the country. We use time series data for maize yield and area share in Zambia collected from FAO statistics. After all the tests, our results indicate that the area share and maize yield has no unit root and is stationary after first differencing, integrated in the first order (I(1)). Additionally, a unit increase of the area share of maize has 2% decrease of maize yield in the next season owed to excess stock, and price variability. We estimate the area share of maize to have an average growth of 764.884 cwt/ha while maize yield is estimated to have an average growth of 16597 kg/ha. Our findings also attest that to drive green and sustainable agricultural growth in Zambia, there is need to mitigate soil, water and air pollution emanating from the mining quarries and manufacturing industries, precisely for farmer situated near mining zones. This requires amendment of land allocation and dumping policies in farming ecological zones. As the current policies tend to be inefficient in ensuring green growth among farmers and the country as a whole. Thus, there is need to embrace new farming technologies from land preparations to efficient but cheaper crop storage facilities. There is also need to embed the use of unexplored organic farming systems using compost which is safe, and substitute for chemical fertilizer in order to ensure high yield while conserving ecological zones in Zambia.

**Keywords**

Forecasting, Area share, Yield, Error Correction Model, Co-integration, Maize and Zambia.

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The environmental costs of fashion: a case of jeans

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Abstract

Fashion industry is considered as one of the most polluting industries in the world. Every stage in an apparel’s life cycle, from the attainment of fiber to the disposal (which is termed as “cradle to grave”), threatens our planet and its resources. The purpose of the study is to compile a dataset concerning jeans and its life-cycle environmental emissions under various reduction scenario. Firstly, we systematically assessed the environmental impacts of jeans based on life cycle assessment. Specifically, the life cycle consists of production of cotton fibers, fabrics and garment, use, and end of life. A number of scenarios were then built to discuss the strategies of the jeans’ consumption and sustainability. Results show that in global average the process from cotton cultivation to a pair of finished jeans (300g) caused 17.9 kg greenhouse gas emissions (measured by CO2 equivalent) and consumed 1456.2 kg of water. During total process of jeans production, the majority greenhouse gas emissions stem from fabrics production, which accounted for 69%. However, 92% of water was consumed in cotton fiber production phase. Scenario analysis indicates that measures including cotton fiber replaced by organic cotton or mixes with artificial fiber, modifying consumption patterns, improving consumer behaviors and implementing recycling have great potential to reduce environmental footprints of jeans.

Keywords
Environmental footprint; life cycle assessment; fashion industry; sustainability

An improved gray water footprint model to analyze virtual water flow in China

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Abstract

Renewable energy RE (solar, wind, energy storage) is the gateway to to addressing the urgent need to decommission highly pollutant fossil fuel energy generation, as emphasised by the IPCC 1.5 degrees report. These socio-technical transitions (using Geels term), outlined in the 2015 Paris Agreement on Climate Change, as central to nation state commitments to transitioning to a global low carbon future but with limitations for energy justice for developing countries and the Global South. To advance this future agenda, renewables products and materials choices need to be sustainable and ethical. But key components of RE systems demand increasing amounts of green or ‘technology minerals’ [a term coined by Jack Lifton in 2007]. These include conflict minerals (tin, tantalum, tungsten and gold), and critical materials including rare earths, as recognised by for example, by the EU, the United States Geological Survey and GeoScience Australia. Internationally, supply chain governance and public policy requirements are increasingly aligning with circular economy concepts.

However, there is little analysis of the key regulatory facilitators and obstacles to better alignment of RE technology minerals/materials used in renewable energy wind, solar and battery storage products and systems with circular economy as well as energy justice across developed-developing economies.

Based on interdisciplinary research, this paper overviews conflicting notions of circular economy, how circular economy principles might be applied to future issues regarding international governance and regulation of conflict and critical technology materials, and critiques the limited framing of key international governance issues by for example the World Bank 2017 report on The Growing Role of Minerals for a Low Carbon Future. It concludes on the need to go beyond the mismatch between supply and demand and advantages for resource-rich countries, to ways of enabling future sustainable, ethical and just, energy transitions.

Keywords

circular economy, just transitions, critical materials, supply chain

Beyond the Circular Economy; Exploring the Consequences of its Accelerated Adoption

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Abstract

Background: The Circular Economy is slowly gaining ground. With an increased amount of research in the field, growing an expected 34.9% between 2016 and 2019 when looking at the amount of published papers, and more relevant regulation being passed, the Circular Economy is steadily increasing its adoption rate. It is expected that at a certain point the adoption of the Circular Economy will start to accelerate extremely fast before reaching a stabilization point (Bosmans and Rotmans, 2016). In doing so it will replace the old linear economy and create a better sustainable society.

This is likely to only happen with the correct policies in place and/or other external drivers, such as worsening environmental problems causing a cultural shift or an increase in resource prices due to increased scarcity. At the same time, the rate of adoption of Circular Economy practices is influenced by resistance to changes and disputed social processes. In this view it is important to have an understanding of the possible socio-economic scenarios arising from the effects that this would have before it happens.

Problem Statement: Under the assumption that the Circular Economy reaches a take-off point in the (near) future and accelerates rapidly to replace the linear economy, it is important to consider the consequences that such a disruptive change
generates on the pre-existing equilibria. As the Circular Economy takes off, the linear economy could very well crash down as it loses the scale and scope advantages on which it has come to rely for the extraction of many resources.

This research aims to look at the societal consequences of an accelerated adoption rate of the Circular Economy. It is critical that any potential downsides to society, by a fast adoption, will be mitigated if we want to make sure the Circular Economy keeps growing into a “new” dominant economic model. This has to avoid a rebound to the linear economic model.

Study Design: The study is based on two phases. The desk phase is addressed to an analysis of both the scholars’ interpretation of the transition towards the Circular Economy and the extant literature on applications and practices of Circular Economy. Then, in the field phase, interviews with subject matter experts are held to assess the validity of the problem statement and the emerging interpretations. The research will be exploratory in nature and is aimed at developing hypotheses for future research.

Results: With the advent of the Circular Economy, the linear economy shrinks, its scale and scope advantages will be reduced and the cost of producing virgin materials will go up. Secondary materials of the same quality as their primary counterpart are not always competitively priced to virgin materials, because virgin material prices include less of their actual cost. This is expected to cause an interruption of the existing balance and the occurrence of a huge market uncertainty situation.

In fact, if the increase in resource prices is not balanced by a lower demand, this can cause a recession with negative effects on welfare (defined as level of living). As resource prices go up, the supply of products would go down. Followed by a reduction in production and increase in price levels. If products do not retain their value better, e.g. through eco-design allowing for longer/multiple life cycles, this would lead to a reduction in welfare.

Conclusion: Society will have to move away from its current trend of increased consumerism and gain welfare from a more sustainable use of the resources in circulation, ahead of an accelerated adoption of the Circular Economy. If the top of the waste hierarchy is not adequately represented during a period of accelerated adoption of the Circular Economy, it will have negative effects on welfare. The current trend in Circular Economy adoption is mainly focused on lower tiers of the waste hierarchy, such as recycling & incineration. The latter are closing the loop in terms of production but do not directly promote a more durable use of products. To keep levels of welfare intact under less production occurrence, products will have to gain increased lifecycle lengths and retain their value better over the lifecycle(s).

It is key to the success of the Circular Economy perspective to adopt views that overcome the waste production/recycle approach. Society has to assume a new (eco-)design product approach aimed to make the life of the products longer and its components and materials completely usable over multiple life cycles. On the opposite, if the top of the waste hierarchy is not adequately represented (Prevention & Reuse/Repair/Remanufacture), thus not increasing a product’s value retention, higher resource prices will lead to lower welfare. This in turn will trigger a rebound effect to the Linear Economy and the Circular Economy would fail to stabilize as the dominant economic model.

Keywords
Circular Economy; Linear Economy; Welfare; Life Cycle; Resources; Production.

An inexact simulation-based stochastic mixed-integer programming model for the management of watershed nutrient export from diffuse sources under uncertainty

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Abstract
Diffuse source pollution is one of the most primary causes leading to water environment deterioration and ecological degradation. It has become an important factor threatening human health in many regions. Therefore, it is necessary to scientifically analyze the characteristics and seek some effective controlling methods and management modes of diffuse source pollution in typical watersheds. However, many challenges exist in the real-world management systems of diffuse source pollution, including multiple system uncertainties and risk of excess nutrient discharge. Some methods must be proposed and improved to effectively deal with these system complexities. In this study, an inexact simulation-based stochastic mixed-integer programming (ISMIP) model is developed to support feature analysis and optimal management of watershed nutrient export from diffuse sources under uncertainty. System uncertainties, such as discrete intervals, integers and random distributions in both simulation and optimization processes, can be effectively dealt by the model. Also, the model can establish a direct connection between the randomness in the simulation process and the optimization results. The developed ISMIP model is applied to a real-world case study in the Dongjiang River Basin in South China. Results show that the total loads of dissolved nitrogen and phosphorus exported from the diffuse sources in the Dongjiang River Basin was approximately 24,939.76 and 806.68 t, among which inorganic nutrients were the main forms. Subbasins, including Xunwu, Beiling, Gongzheng, Shima River and the main stream watersheds, are the critical source areas of this area. Meanwhile, agricultural production and fertilizer application need to be adjusted to mitigate the diffuse source pollution. The model can provide multiple decision alternatives for the watershed policy makers to consider agricultural production and water environment protection. The proposed ISMIP model has a good applicability and can be utilized for the management of watershed nutrient export from diffuse sources under uncertainty.
Keywords
Diffuse source pollution; Nutrient export from watersheds; Optimization management under uncertainty; Inexact stochastic chance-constrained programming; Mixed-integer programming.

Spatiotemporal patterns of carbon emissions between cities in Pearl River Delta, China
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Abstract
The research of the dynamic distribution characteristics of carbon emissions and their evolution rules have important theoretical significance for formulating reasonable carbon emission reduction policies between regions, to achieve carbon reduction targets. This paper aims at measuring the carbon emissions generated by industrial energy consumption in each city in Guangdong Province during 2005-2015, and empirically analyzing the distribution dynamics and evolution of inter-regional carbon emissions. The conclusions of the study show that, during the study period, there was significant spatial non-equilibrium in industrial carbon emissions in Guangdong Province, carbon intensity in the urban agglomeration was less than that of the peripheral cities; the standard deviation ellipse results showed that the overall gap in the spatial distribution of industrial carbon emissions showed an expanding trend. Among them, Western Guangdong showed an expanding trend, while Northern Guangdong showed a downward trend; the Kernel density results indicated that the carbon intensity of carbon emission decreased; Markov chain analysis showed that different levels of carbon intensity group was indicative of a certain stability of carbon emissions. On the whole, regional carbon emissions have a downward trend, alongside with the change of the radiation characteristics of spatial differentiation of carbon reduction of the region. The carbon emissions of urban agglomerations were greatly reduced, with the external strong radiation. The carbon emissions of peripheral cities are growing rapidly with economic growth. The formulation of carbon emission reduction policies should be tailored to local conditions. Economic developed cities should undertake more emission reduction obligations and promote the coordinated development of underdeveloped cities; rational allocation of productive elements between urban agglomeration and peripheral cities helps to achieve low-carbon development.

Keywords
spatiotemporal pattern, standard deviational ellipse, Kernel density, Pearl River Delta

Circular Economy in the Agro-industry: Environmental Assessment of Dairy Products
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Abstract
Worldwide urban systems and surrounding regional economies are affected by the resources availability, urban-rural asymmetry, increasing municipal and agro-industrial waste and serious locally and globally environmental problems. Understanding cities becomes increasingly crucial concerning: (i) their relationship with the environment, (ii) the internal dynamics of resource exchange among city components and sectors, (iii) the competition among cities for scarce resources, as well as (iv) the interlinkages among components and processes in the urban-rural balanced collaboration.

Therefore, the implementation of new Circular Economy (CE) pathways in urban, agricultural and industrial sectors, to increase recovery and recycling of residues and waste towards innovative business models able to optimize the resource use and to increase the environmental performance, becomes crucial.

The dairy system, with its international value chains and highly diverse farming practices (from intensive to extensive livestock models and from small-family business to industrial chains), is a major driving sector for rural economies and world nutrition. However despite the potential for further growth, the dairy sector is currently facing an important challenge toward the implementation of sustainable supply chains and innovative circular economy patterns to repurpose dairy wastes as new opportunities for eco-friendly revenue streams based on green energy and bio-based value-added products (COM(2010) 672; COM(2015) 614, European Commission, 2018). In Italy, the dairy sector is a significant example of a complex sector, particularly differentiated in demand and supply segments, and increasingly integrated with the EU and international markets, particularly with regard to denominations of origin (e.g. DOP, IGP). Italian dairy products are considered to be the most qualitative and diversified worldwide. They are characterized by a strong regional diversification, with about 30 brands showing higher market value than those of others cheeses in the international market. However, the national sector is also affected by regional disparity, that seeks against generally dynamic and rational animal husbandry. In Italy, the Regions with the highest concentration of dairy companies are Campania (about 20%), Emilia Romagna (about
In Campania region, the dairy production chain is an important segment of the regional agri-food economy, both in terms of economic value activated and as an image of the products appreciated on national and international markets. This shows, on the one hand, the tradition and the vocation of the territory for this type of activity and, on the other hand, suggests that there are great economic opportunities for companies dealing with hygiene, preservation and milk processing. By evaluating the characteristics of dairy companies, there is a very heterogeneous compartment that includes dairies and dairy centers, farms, cooperatives and collection centers. In general, in Campania Region, the least common denominator of the various producing entities is the reduced size of the companies, with small and family business management, often characterized by poor automation and predominant craftsmanship in milk processing dairies.

The livestock sector comprises cattle, buffalo, sheep and goat, reared through both extensive grazing and housing feed. The buffalo chain in Campania region has elements of greater heterogeneity, both in terms of farm size and organizational factors (e.g. technological aspects or distribution of products). For this reason this work aims to evaluate the Buffalo Mozzarella cheese chains (fresh kneaded-curd cheese is a typical dairy products in Campania Region) using Energy Accounting (EMA) and Life Cycle Assessment (LCA) methods towards the optimization of energy, materials and environmental performance in order to contribute to the improvement of the Campania Region agro-industrial economy, within a circular economy perspective. Replacing fossil energy sources with renewable ones, preventing resource waste and waste generation in production and consumption, transforming waste materials into power and bio-based degradable products with high added value (chemicals, food additives, fertilizers, energy), would be crucial patterns toward the implementation of advanced buffalo dairy production chains, in so contributing to the development of a more sustainable agro-industrial chain, from social, economic and environmental points of view.

Keywords
Circular economy; Livestock; Dairy Sector; Life Cycle Assessment; Energy Accounting.

Wine production: A look into circular opportunities

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Abstract

Grape wine represents one of the most important alcoholic beverages in the world, with a steady growing demand and supply. The industry is largely dominated by the “Big Three”: Italy, France and Spain. This paper identifies the environmental burdens and potential benefits associated with the wine making process in the Northern region of Campania, Italy, using the LCA methodology. Wine making is a timed, multistage process that produces a large amount of organic and inorganic waste. For example, during grape processing a substantial volume of solid waste is produced. The residues represent approximately 20% of the dry matter of the harvested grape. An environmental assessment of the entire process is performed by means of LCA, providing a quantitative understanding from the vineyard to the plant processing (taking the vineyard Numeroso to Asprinio DOC as a case study).

The study aims to understand to what extent wine production from the vineyard to the wine bottle is environmentally sound and if there are areas that need intervention along the value chain as well as explore potential opportunities to convert residues into valuable co-products (chemicals, food additives, fertilizers). Indeed, winery waste has an influence on culture and high impact on the economy as well as environmental aspects to deal with, since its proper disposal represents an additional cost for the wine industry, while inappropriate treatment can contribute to airborne and waterborne emissions, soil pollution, landscape damage. Therefore, an appropriate performance of the production chain as well as the environmental feasibility of wine wastes re-use must be addressed in order to fully exploit the process potential and meet the EU directive on Circular economy.

Indeed, since wine wastes are produced in large amounts, their treatment and conversion within a biorefinery framework could contribute to the creation of new production chains and, therefore, new markets. Such a scenario would entail an increase of the sustainability of wine industry, which on a larger scale would serve as a proactive model for the whole food industry.

Keywords
Wine waste, Circular economy, LCA

Circular economy paths in the olive oil industry: A Life Cycle Assessment look into environmental performance and benefits

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Abstract
Agricultural production is a sector with high socio-economic significance and key implications on employment and nutritional security. However, the environmental impacts of agri-food production and consumption patterns are quite significant, mainly due to the demand of large inputs of resources (fuels, chemicals, disposal of residues). The paper presents the results of an LCA based analysis of the production of olive oil in the Campania region of Italy. The aim of the study is to assess the energy and environmental impacts of an organic olive farm and olive oil production in order to assess the contribution of each life cycle step to the energy and environmental impacts. All key parameters that are associated with the life cycle of olive oil production are observed and environmental “hotspots” are carefully analysed. In order to increase the sustainability of the process, also by-products conversion to a set of marketable products is assessed (chemicals, fertilizers, energy) and the potential of the entire direct and reverse chain is explored. The analysis is carried out according to the LCA standards of the ISO 14040-14044/2006 series. The study is based on a field analysis developed in representative farms and industries of Campania region and the data used for the development of mass and energy balances is related to the year 2018. Environmental impacts are observed at both sub-systems (cultivation of olive trees and olive oil production phase). Performance improvement options and additional efforts for valorisation of by-products are explored as a way to minimize the impacts along the life cycle of the olive oil production chain and increase the sustainability of the whole sector, within a circular economy perspective.

Keywords
Olive oil, LCA, circular agriculture.

Assessing potential for resource efficiency and cleaner production in Zimbabwe brick industry
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Abstract
Zimbabwe faces housing problems due to the ever-growing urban population. Governmental Vision 2030 Program plans to build 800,000 new houses. It is envisaged that the brick manufacturing sector will play a pivotal role in providing the much-needed construction material for this vision to become a reality. This paper presents a Life Cycle Assessment (LCA) study that quantified the environmental cradle-to-gate impact of the manufacturing of bricks for the construction industry, produced with clay material source. The LCA results for brick manufacture using clay material identified the greatest environmental impact to be associated with clay material extraction and air emissions. Additionally, this paper assesses the potential for resource efficiency and cleaner production in the brick industry in Zimbabwe and presents alternative green options as interventions to minimize environmental damage. The monitoring of brick kiln emissions was carried out on an 8-hour basis during the non-operational and operational phases of brick kilns in the period from August to November 2018, in order to quantify the levels of gaseous pollutants like sulphur oxides (SOx), nitrogen oxides (NOx), particulate matter (Respirable particulate matter-RSPM and Non-Respirable Suspended particulate matter NRSPM).

The results revealed that all the monitored pollutants were exceeding the limits prescribed by Environmental Management Agency (EMA) during the operational phase of brick kilns. Further, the air quality index (AQI) was calculated and the study sites were categorized from severe to high pollution areas including residential areas which source of major concern, in consideration of the health conditions of the local people. To minimize the emission level of air pollutants from brick kilns, possible interventions of air pollution mitigation measures are suggested. In conclusion, the study shows that a large quantity of clay is inefficiently used and unaccounted for both during extraction and brick production phases and air emissions are of great concern in this particular sector of the construction industry in Zimbabwe, calling for urgent and effective measures to improve production technologies in the construction sector.

Keywords
Brick Manufacturing, Clay, airborne emissions.

Environmental impacts of apparel production: a case study of jeans
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Environmental impacts of apparel production: a case study of jeans
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Abstract

Apparel industry is considered as one of the most polluting industries in the world. The process of turning raw materials into finished apparel has significant negative environmental implications, including air and water pollution. The purpose of this study is to analyze the environmental life cycle performance of a pair of jeans. We systematically assessed the environmental impacts of jeans production based on life cycle assessment. Values are calculated for the following environmental impacts indicators: global warming potential, ecotoxicity, freshwater eutrophication and water consumption. Specifically, the life cycle of jeans production consists of cotton fibers production, fabrics production and garment production. Here we show that, in global average the process from cotton cultivation to a pair of finished jeans (500g) caused 77.9 kg greenhouse gas emissions (measured by CO2 equivalent) and consumed 1456.2 kg water. During total process of jeans production, the majority greenhouse gas emissions stem from fabrics production, which accounted for 69%. However, 92% of water was consumed in cotton fiber production phase. Electricity consumption is the main contributor to the environmental impacts of jeans production. The results highlight the differences in environmental impacts between countries due to technical level differences. It is necessary to measure the environmental impacts of localizing production in the market.

Keywords

Environmental impacts; life cycle assessment; apparel industry; jeans; sustainability

Developing a procedural method for the integration of Life Cycle Assessment and Emergy Analysis. The Amalfi paper case study

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Abstract

To solve a problem, we need to understand both the inner mechanisms and the way the problem is controlled by the larger surrounding system. To this aim, a defined, commonly accepted framework has to be implemented for the comparison of similar products or processes. The simultaneous application of different assessment methods may be advantageous in the perspective of looking at systems and/or processes from different scales and points of view in order to gain a systemic understanding of the investigated case study (as H.T. Odum used to say, a "macroscope" is needed to look at a system "from the next larger scale"). Life Cycle Assessment (LCA) and Emergy Analysis (EMA) are both environmental assessment methods, showing many similarities in the way they are performed, especially with respect to the inventory construction and to the interpretation of results. Though, they also show great differences, the main residing in their perspective when applied to a system. LCA applies a "cradle to grave" approach focusing on renewable and non-renewable resources under human control. LCA consumer side perspective delivers information about the impacts generated by the system under investigation in different environmental compartments in terms of emission and resource depletion. EMA on the other hand, throughout its donor side perspective, expands the boundaries of the system over the entire biosphere space and time scales, accounting for the energy embodied in resource generation, including direct and indirect labor. Previous research has considered EMA as an upstream LCA impact category, trying to merge the two methods in feasible software. LCA was designed to address specific questions (e.g. pollution, resource depletion) and quantify environmental performances at local or regional space/time scales. Emergy addresses different questions (sustainability, cost and time for resource generation, resource quality, interplay of economy and nature, natural capital and ecosystem services, etc) at larger space/time scales (we consider emergy as a "macroscope", in that some processes can only be understood looking at them from the next largest scale). LCA and Emergy are designed for different purposes. When we jointly use LCA and EMA, we answer to two different sets of questions, both very important and much needed. Thus, differences and similarities between LCA and EMA may gain added value by their implementation within a procedural framework which exploits the characteristics of the two methods. We should be aware, however, that due to their different definitions, integration may not always be feasible, in that some answers require LCA and other answers require EMA. Coupling the two approaches requires being able to understand when they can be effectively applied and how we can integrate their results.

The present work proposes a methodological procedure based on the sequential and integrated application of LCA and EMA methods. The Amalfi paper production, a traditional high end quality paper produced in southern Italy, is used as a test case study. The procedure stems from an ex-ante LCA analysis, to understand the hot-spots of the investigated case study. The second step is the assessment of the environmental performance of the system through the development of different EMA-based scenarios introducing a random variation, within a chosen range, of the magnitude of the identified hotspots. The scenarios are defined as: a) Business As Usual (BAU) scenario, evaluating the system as it is with the random variation accounting for the normal fluctuations and for the common sense in the management of the identified hotspots; b) Technology-based Efficiency Improvement (TEI), to suggest improvements of the investigated level through energy and
material technological efficiency, according to the LCA approach; c) Eco-Efficiency Implementation (EEI), i.e. achievable improvements of the environmental sustainability by substituting energy and material hotspots with renewable or less environmental costly input flows (less specific energy) according to the EMA approach. In the investigated case study, scenario based with different paper production processes and paper qualities. Scenario results in different environmental burdens detectable by an ex-post LCA application. Depending on the total energy investment needed in each scenario, the investigator is able to understand the viability of any specific improvement and the sustainability of the investigated process.

**Keywords**
Life Cycle Assessment; Emergy Analysis; Integration; Paper production.

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**Planning and policy strategies for tomorrow’s sustainable cities. Potentials of circular buildings explored through systems thinking and emergy accounting.**

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**Abstract**
Sustainable cities are often envisioned in an ethereal future, thus losing concreteness and perspectives of action. If it is true that land consumption is a serious issue in contemporary cities, and that the reuse and refurbishment of the existing built environment seems more and more as a must, we maintain that building design also needs adequate planning and policy strategies to be accomplished in a sustainable transformational path when new manufactures are required.

With its potentials and limits, the framework of circular economy has been inspiring interesting proposals in all fields, including the construction sector. In very recent years, some designers have been proposing “passports” for building materials to be tracked and reused at the end of an edifice’s life cycle. Some others have included circularity in several aspects of the construction, operation, and dismantling phases. Some have rather focused on some internal systems: water, energy, and even indoor food production.

In the present contribution, we present a selection of interesting proposals for circular buildings. We therefore analyse one of them through the Emergy Accounting method (EMA), rooted in systems thinking, and finally assess their potentials in the path towards sustainable cities.

In order to reinforce our scientific scholarly work, we also sketch some planning and policy strategies to be submitted to practitioners and policy-makers for a possible adjustment as well as for a more effective implementation of best practices in circular building.

**Keywords**
Construction and demolition waste; Circular economy; Urban metabolism; Urban planning and policies.

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**Economic and Resource Environment Carrying Capacity Trade-off Analysis of Haihe River Basin in China**

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**Abstract**
Resources and environment are the fundamental conditions for human beings to live on. With the increasingly prominent contradiction between regional socio-economic development and resource and environmental issues, international attention on sustainable development issues was increasing. Coordinating the relationship between resources and environmental protection and socio-economic development is a necessary measure for human to pursue sustainable development. Researchers have promoted the improvement of the concept and research means of carrying capacity, but few have further described the changes of regional comprehensive carrying capacity from the perspective of the relationship between socio-economy and resource and environment carrying capacity, which can provide decision-making basis for regional sustainable development. Haihe River Basin is a significant high-tech industrial region in China. The Beijing-Tianjin-Hebei region in the basin is rich in concentrated innovation elements and China attaches great importance to it. At present, Haihe River Basin is facing the development dilemma of restricted resources, environment and socio-economic. The contradiction between the rapid development of socio-economic and the decline of the carrying capacity of resources and environment is increasingly prominent. It has become an important proposition of the basin development to develop the economy of Haihe River Basin urban agglomeration, while effectively ensuring the benign cycle of environment and ecology. Besides, it is also crucial to improve the living standard of the people and promote the coordinated development of economy and society with a good comprehensive carrying capacity. It is necessary to improve basin’s and coordination degree level of carrying capacity to promote the green development of basin.
To explore socio-economic and resources carrying capacity evolution of Halhe River Basin, 26 indexes, such as socio-economic and resource environment from 2000 to 2016 were selected based on PSR model selection. PSR, namely pressure-state-response, is an evaluation model commonly used in the sub-disciplines of ecosystem health assessment in the discipline of environmental quality assessment. As an objective weight method, entropy method can make the index data more comprehensive and objective to reflect the information contained in it. Exponential smoothing method, also known as exponential weighted average method, is a time series analysis prediction method based on moving average method. R/S analysis method is a time series analysis method which can be used to judge the fractal structural characteristics and long-term memory process of time series, and is a scientific nonlinear prediction method. Constructing the comprehensive capacity of Halhe River Basin evaluation system, TOPSIS model of entropy, the exponential smoothing method, R/S analysis were employed as methods for evaluating and analyzing capacity level’s characteristics and development trend.

The results showed that from 2000 to 2016, the level of comprehensive carrying capacity and its subsystems in Halhe River Basin changed dramatically. The level of socio-economic carrying capacity and talent carrying capacity increased significantly, respectively by 0.954 and 0.939. The level of comprehensive carrying capacity, resources and environmental carrying capacity declined constantly in the first ten years of the study period and leveled off after 2011. The resource and environment carrying capacity of Halhe River Basin was negatively correlated with the socio-economic carrying capacity, while the talent carrying capacity was positively correlated with the socio-economic carrying capacity. These three sub-systems of carrying capacity restricted and influenced each other, and took the economic carrying capacity as the leading factor. However, in the later stage of development during study period, resource and environment carrying capacity became the key to improve the comprehensive carrying capacity of Halhe River Basin. According to the forecast results, from 2017 to 2021, the level development of each capacity subsystem illuminates a strong sustainability with varying degrees of increase, among which the level of socio-economic bearing capacity will maintain a continuous and rapid rise trend. The comprehensive carrying capacity level of Halhe River Basin would be stable and rise in the future development, and the predicted value reaches 0.23 in 2021. The level of resource and environment carrying capacity basically remained stable, only increased by 0.01. Economic capacity and talent capacity will continue to rise, with predicted values of 1.47 and 0.98 respectively in 2021.

This research makes a trade-off analysis between the socio-economic and resource and environmental carrying capacity of the Halhe River Basin. The study will provide theoretical basis for the coordinated development of various carrying capacity, which has reference significance for promoting the sustainable development of the River Basin.

Keywords
Halhe River Basin; carrying capacity; TOPSIS model of entropy; sustainable development.

Life cycle assessment of building materials: a case study of a Brazilian house using conventional masonry, light steel framing and light wood framing

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Abstract
Civil construction is among the main sectors responsible for the greatest environmental impacts in the world, partly due to the cement industry. As alternatives to the construction system in conventional masonry (CM), composed of reinforced concrete and ceramic bricks and consumes large quantities of cement, there are prefabricated systems such as light wood framing (LWF) and light steel framing (LSF).

In this context, this study aims to simulate and compare the environmental impacts of a standard low-income house, single storey with approximately 40 square meters, and analyse the environmental behaviour of a traditional building for the Brazilian reality throughout its life cycle using CM, LWF and LSF building systems. The product system presents a cradle-to-gate LCA: extraction of raw materials, manufacturing materials, transport, manufacture and house construction; transport and replacement of materials in use; recycling and final disposal.

To achieve more precise results, inventory was adapted from world average to the Brazilian electricity matrix. Results were evaluated according to: i) the life cycle phases; ii) the construction materials used in the pre-operation; iii) the construction stages (substructure, superstructure, walls and roofing); iv) the comparison between the three construction systems and v) the comparison between the adapted and the original base data. The development of the LCA followed the structure presented in ISO 14040 and 14044, using SimaPro 8.5.2.0 software, Ecoinvent 3.4 database and results were evaluated according to IMPACT 2002+ method.

The total mass of materials used in the construction process were, for each system, 79,646,85 kg (CM), 36,840,05 kg (LSF) and 30,121,41 kg (LWF). The amount required during the replacement step was 43,982,54 kg (CM), 5,823,35 kg (LSF) and 7,918,88 kg (LWF). The destination of each material was defined according to the classification criteria of CONAMA Resolution No. 397/2002, with the possibility of disassembly without contamination and whether the discarded material has market value. Waste disposal destinations were considered as inert landfill, landfill, hazardous waste landfill and recycling based on their classification, type and characteristics. The disassembled materials of the CM house destined to landfill inert waste were 99% and 1% to hazardous waste landfill. In the LSF, 62% of the disassembled materials were sent
to inert landfill, 27% to landfill, 6% to hazardous waste landfill and 5% to recycling. In the LWF house 71% to inert landfill, 23% to landfill, 5% to hazardous waste landfill and 1% to recycling.

For all three construction systems, pre-operation was responsible for the greatest impacts, followed by operation and post-operation. Regarding CM, pre-operational phase corresponded to 59.9% of the entire life cycle impacts, followed by operational (35.8%) and post-operational (4.3%). The materials that most affected the categories evaluated were ceramic block, Portland cement and ceramic tile, responsible for the average of 60.7% considering all impact categories. As for the impacts of the construction stages, walls were the main construction stage in relation to the evaluated impacts, followed by the roofing, substructure and superstructure.

In the LSF construction system, pre-operational phase was responsible for 71.8% of all impacts during life cycle, the operation for 21.9% and post-operation 6.3%. Most relevant materials and processes in terms of impact categories were steel and zinc coating treatment, with 26.6% in average. Analysing the construction stages, superstructure presented the highest contribution, then walls, substructure and roofing, respectively.

In the LWF system, 58.5% of impacts in the life cycle were related to pre-operational phase, 35.8% to operational and 5.7% to post-operational. The most important impact contributions were attributed to OSB, pinus and ceramic tile, with 50.2%. In terms of construction stages walls were responsible for 33.4% of impacts, roofing 26.7%, substructure 21.2% and superstructure 18.7%.

Comparing the environmental impacts of the construction systems analysed, CM presented the largest contributions, with 37.7%, as the main contributor to the impacts: non-carcinogens, respiratory inorganics, ionizing radiation, ozone layer depletion, land occupation, global warming and non-renewable energy. In sequence is LSF with 31.3% of impacts and the most relevant participation in the following impacts: carcinogens, respiratory organics, terrestrial ecotoxicity, terrestrial acidification, aquatic acidification, aquatic eutrophication and mineral extraction. The lowest impacts were attributed to LWF, with 31.7% in the category aquatic ecotoxicity.

Given the results presented, the most environmentally interesting is LWF construction system, considering the limitations and criteria adopted in the LCA. The use of this system in Brazil is still scarce and it is expected that to arise in the next years, which can lead to a solution in both environmental and social terms.

Regarding the LSF system, although its average impact was similar to LWF, it presented the largest contributions in several of the evaluated impact categories. In this sense, both LWF and CM can be environmentally interesting if adopted sustainably sourced materials. Another issue is the high material waste that occurs in CM, so focusing on reducing these losses can be a strategy to reduce environmental loads.

With the adoption of the database to the national electricity matrix it has been proved that the national energy matrix can be considered more sustainable than the world average, however the Brazilian government must invest in clean forms of energy generation to maintain and improve the current performance.

The research conducted contributes to the still incipient scenario of national LCAs in the area of construction, when compared to countries such as China and the United States. Environmental concerns have become increasingly popular, reaching the construction market today and serving as a draw for new home sales. This LCA study provides an overview of the environmental characteristics of the materials employed and the most environmentally relevant construction steps, supporting decision making about more environmentally sustainable building materials and systems.

**Keywords**

life cycle assessment; conventional masonry; light wood framing; light steel framing.

**Digital Twin in Circular Economy: From the Perspective of Reusing and Remanufacturing**

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**Abstract**

At present, due to environmental degradation and increasingly scarce resources, the circular economy and the local recycling industry chain have attracted a lot of public attention. How to rationally use solid waste and promote the production process of different industries from the open loop to the closed loop is a concern of governments. Despite many policies introduced by governments, the current solid waste recovery rate is still very low, especially in the reuse and remanufacturing process of solid waste. It illustrates that there are currently some factors that hinder the recycling of solid waste. The utilization of this part of waste is beneficial to the development of circular economy. However, because many companies cannot fully realize the value of manufacturing and reuse, or because of information communication, enterprises are lack of motivation for reusing and remanufacturing in the circular industry chain. Digital twin is a heated-discussed issue in current academic circles, as it facilitates more transparent information exchange. It provides a potential solution for reusing and remanufacturing in the circular economy industry chain. However, most End of Lifetime (EoL) products-treatment related researches currently are focused on recycling process, while few researches concentrate on reusing and remanufacturing process. This study summarizes the current research on reusing and remanufacturing processes of circular economy, and the different characteristics and challenges of digital twin in the application of circular economy are analyzed from different industry perspectives. Besides, this study provides a potential research direction for future research on reusing and remanufacturing aspects and corporate information flows. The contribution of this paper...
is mainly reflected in two aspects. Theoretically, this paper finds the application limitations of digital twin and the method defects of the reusing process and remanufacturing process in circular economy. Practically, based on the summary of previous studies, this paper attempts to provide possible solutions for the tracking problem of EoL (End-of-Lifetime) products in the reusing and remanufacturing process in the current circular industry chain.

Keywords

digital twin; circular economy; reusing and remanufacturing; application and method review.

Four-sector game model on rent-seeking of new energy enterprises under the green credit policy

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Abstract

Climate change has aroused the increasing attention from governments and the public. Numerous countries have been subsidized the emerging energy industry directly or indirectly to boost the development of the new energy industry. Because of information asymmetry, some enterprises defraud the government of subsidies, and some local governments also have rent-seeking behavior, thus adversely affecting the implementation of the policies. In this study, a model is built, covering four departments, central government, local government, energy enterprises and banks. This model is employed to analyze the principle of the rent-seeking issue and the mechanism of implementation of green credit (e.g., government subsidized loans) measured by central government to local governments and enterprises. According to the results, first, the bribery probability will be down-regulated with the rise in the amount of bank loans, whereas it is up-regulated as bank interest rates grow. Second, the fines of enterprises should reach a certain amount, allowing enterprises to take energy-conserving and emission-reducing measures. Third, only when the central government departments properly punish the enterprises failing to implement the environmental protection measures can the banks are motivated to lend to the enterprises. In the present study, the rent-seeking model is extended to the application of green credit, and suggestions are proposed on government policy-making from the perspective of green financing.

Keywords

optimal model; green credit; rent-seeking; central-local governments; enterprises; bank

Circular Economy in the regional context: A systematic literature review and bibliometric analysis

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Abstract

The unprecedented adverse consequences resulting from the current unidirectional system of large-scale production and irresponsible consumption over the past decades are alarming. The annual extraction of virgin resources has scaled up threefold in the past 40 years (Ekins and Hughes, 2017), which certainly is a denouement of proliferated consumption of those resources. According to McCarthy et al. (2018) the striking growth in demand has been triggered by the accelerated industrialisation of the developing countries and the steady levels of high consumption in the advanced economies. Nevertheless, the material consumption differs significantly at a regional level, leaving the emerging countries far behind the developed world (Wiedmann et al., 2015). Moreover, recent evidence has revealed notable incongruity between the rate of consumption and replenishment of the natural resources, the former being 50% higher. Future projections concerning the consumption of natural resources are also worrying, predicting two planets worth of virgin resources to meet global demand by 2030, and three planets by 2050 (Siegel et al., 2014).

Taking into account these rapid changes and the negative impact they have, the transition from linear to a more regenerative economy is unavoidable (Esposito et al., 2018). Hence, the notion of Circular Economy (CE) has emerged, which by entailing the paradigmatic shift in itself promises a more systematic and holistic change. The concept of CE, as defined by the European Commission (2015) focuses on optimizing the value and usability of resources, materials and products as long as possible, while minimising waste. The disruptive nature of the CE paradigm not only aims but exactly redesigning the dominant production and consumption systems in such a way to “close the loop”, by retaining highest utility and minimum waste. CE elaborates the industrial ecology and environmental economics concepts to an economy-wide system level, with the ultimate goal to decouple economic growth from resource consumption and resource utilization (Ghisellini et al., 2016). The body of literature to date has been tackling the implementation of the CE at various levels (micro, meso, macro) and with various approaches (bottom-up, top-down). Although the interest in the CE discourse has considerably increased both as an attempt for theoretical conceptualization and practical implementation (Geissdoerfer et al., 2017), the
generalizability of much published academic papers regarding the definition and the boundaries of the concept is problematic. Several scholars justify the inability to reach an academic agreement due to the fact that the CE field is still in infancy stage and it is based in many different disciplines and schools of thought (Blomsma and Brennan, 2017; Bocken et al., 2017), which pose obstacles for both academia and practitioners in building up a sound knowledge base.

The importance of the role of regions as administrative units in the development policy of the European Union is unquestionable. Most of the EU financial resources are redistributed through regionally oriented investment funds which are promoting (directly or indirectly) the transition towards the CE (Avdiushchenko, A., 2018). Additionally, the launching of the program "Towards a circular economy: A zero waste programme for Europe" emphasized the significance of the national, regional and local authorities in providing support not only through policy making and implementation, but also through developing infrastructure, technology and necessary skills for a more successful transition and promoting behavioral change in terms of responsible and sustainable consumption (European Commission, 2014). However, like any transitional process that intends to implement such systematic changes, the potential impact of the CE transition on the regional development is uncertain and ambiguous (Avdiushchenko, A., 2018).

Considering the importance of the role of regions, this paper will attempt to capture the existing knowledge base relating to the CE implementation on the regional level. Hence, the main aim of the paper is to systematically review and synthesise the current academic body of literature and apply bibliometric analysis, in order to uncover potential research gaps which could be addressed in the future. According to Okoli, C. (2015) a systematic literature review ought to be systematic by applying a methodological approach, clear in describing the followed procedures and comprehensive in the scope, hence ensuring reproducibility of the process and the obtained results. The review will be conducted by selecting academic papers from leading journals in the related fields using the Scopus and Web of Science databases as being the most comprehensive and credible. Additionally, both databases have been used extensively in producing systematic literature papers in the field of circular economy (Homrich et al., 2018; Merli et al., 2018; Prieto- Sandoval et al., 2018). A complex keyword structure will be used, using four levels of relevant keywords combined with Boolean operators. Manual screening will be performed and the results will be synthesized, before they will be presented according to pre-selected dimensions. After providing an overview of the CE concept and its linkage with regional development, the relevant stakeholders and governance models that can drive the transition will be analyzed, as well as the involved industries and outcomes that regions are aiming to achieve. Available indicators that measure the circularity of regions will be discussed, as well as advantages and disadvantages of the implementation of CE policies on the regional level. The prevailing research methods and social science theories utilized by authors in this field will also be examined. Hence, this is an important contribution since it will be one of the first attempts to provide an exhaustive analysis of the phenomenon on the regional level. The findings of the study are intended to build up a basis for future research as it will identify the key literature trends and provide implications for the private and public sector, and simultaneously serve as future research agenda.

Keywords
Circular Economy (CE); regions; regional development; systematic literature review; bibliometric analysis.

Comprehensive Analysis and Evaluation of Heating Modes for Steel Residential Buildings
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Abstract
In recent years, the air quality in the northern region has been seriously degraded, and many cities are choosing the right heating system. Under the background of China's energy conservation and emission reduction strategic objectives and improving the air quality in the heating season, northeast China, which has a large amount of heating energy consumption and pollutant emission, also needs to choose a heating system that is suitable for its own development and meets the national requirements.

In order to help the Northeast China choose a suitable heating mode and heating system, first, it need to choose a heating mode that will be widely used in the future. Through research and prediction, by 2021, coal-fired heat sources will occupy the largest market share in the heating market, about 58%, followed by natural gas and electricity. Gas heat sources will occupy 14% market share in the heating market, and electricity will occupy 12% market share. Therefore, from the above three heat sources, coal-fired combined heating and power central heating, large-scale coal-fired boiler room central heating, natural gas boiler room district central heating, natural gas boiler room decentralized heating, regenerative electric boiler heating, electric heating film heating and ground Source heat pump heating are the objects of evaluation and analysis.

Then, with reference to the whole life cycle theory, the evaluation index system covering energy, environment, economy, technology and society is constructed, and the weight value of each index is determined by the analytic hierarchy process. After that, the evaluation index values of each heating mode are calculated by many examples, and the gray correlation analysis method is used to analyze the advantages and disadvantages of the seven heating modes. The following conclusions are drawn:

In the analysis of various indicators, the ground source heat pump heating mode is the most environmentally-friendly and energy-saving heating mode. The emission of atmospheric environmental pollutants per unit area is only about 13% of the large-scale coal-fired boiler room central heating mode. Unit heating energy consumption is about 19% of the regenerative
boiler room heating mode. In the entire heating cycle, the lowest economic cost is the coal-fired cogeneration, which costs only 10% of the regenerative electric boiler. The heating modes that residents can accept are the ground source heat pump heating mode and the coal-fired cogeneration heating mode. Combined with five angles of comprehensive analysis, the advantages and disadvantages of the seven heating modes are not much different. The ideal heating modes are coal-fired hotspots central heating mode and ground source heat pump heating mode. Their gray correlation coefficients can reach above 0.6, and most of the rest are below 0.5.

Through comprehensive evaluation results, the recommended scheme of heating systems in Northeast China is established: coal-fired cogeneration (69%) is the main system, ground-source heat pump heating (4.8%), natural gas boiler room decentralized heating (11.1%), natural gas boiler room area Central heating (5.7%) and electric heating (9.5%) are auxiliary heating systems. The other two heating systems are set up as a comparison. The three systems are compared to reach the final conclusion.

Through analysis, it is found that the energy consumption of the recommended system scheme is very low, and it will save 52,000 tons every year compared with the comparison scheme 1; the emissions of atmospheric pollutants are about 66.7% of the comparison scheme 2, but its carbon dioxide emissions are more than twice as close as the comparison scheme 2. However, after radial analysis, the heating recommendation system is still the closest to the ideal state in the comprehensive evaluation of energy saving, carbon emission reduction and pollutant emission indicators.

Keywords
residential building heating; evaluation index system; analytic hierarchy process; comprehensive evaluation; scenario analysis.

The paradox of food: An input-state-output classification of countries in the global food market
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Abstract
Real world data on efficiency and resource use and the distribution of wealth between countries contradict some specific assumptions of mainstream economics, originating paradoxes. Regarding food, the last decades have mirrored huge progresses in agricultural productivity to target food security goals. These achievements come together with increasing environmental pressure, raising concerns on resource limits and environmental impacts of food production systems. In addition, the fact that the number of hungry people in the world has grown up to the levels of ten years ago (FAO et al 2008), that obesity is affecting the poor in rich countries, and that half of the world’s food is wasted, are questioning the idea that the global market is able to allocate resources in an optimal way. Countries largely affected by food insecurity and chronic malnutrition (such as Sudan) are exporting most of their local agricultural productions, challenging us to reflect on food systems long term sustainability and its implication in terms of economic, social (inequalities) and environmental issues. In this paper, we propose a classification of countries in an input-state-output framework that highlights existing relations among indicators on food imports and exports, local production and consumption, nutrition factors and food security and the environment. This classification informs monitoring national progress on the Sustainable Development Goals (in particular goal 2 on zero hunger), and the assessment of national and international food, agriculture and trade policies, enlightening different sources of country vulnerabilities.

Keywords
economic paradoxes; SDG 2; land-grabbing; inequality; food self-sufficiency; food trade.

Donor-side evaluation of coastal and marine ecosystem services
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Abstract
There is an increasing need for coastal and marine ecosystems conservation. However, information to guide management decisions for coastal and marine ecosystems is still lacking. Considering the present advantages and limitations of existing ecosystem services valuation (ESV) accounting methods, this paper proposes a detailed donor-side accounting approach, based on energy method, which could be used as the basis for better policies-making on coastal and marine conservation. In particular, this includes a classification of different ecosystems, a system for ecosystem services (ES) classification, ES formation mechanism, as well as accounting techniques. The ES classification system includes direct, indirect and existence services. Accounting techniques presented here can overcome common limitations in existing accounting methods: (1) double counting; (2) evaluation from the receiver perspective; (3) the inappropriate use and replacement of unit energy value (UEV). The present method is applied to the evaluation of coastal and marine ecosystems in the Pearl River Delta.
Results show that (1) the total coastal ESV decreased from 2000 to 2009 in the PRD area, among which water purification contributes most to the decrease, followed by soil building, climate regulation and microclimate regulation; (2) the coastal ecosystems have the largest potential to regulate climate whether at micro or macro scale; (3) the marine ESV decreased with the ratio of 42.37%, and biomass increase and carbon sequestration account for the decrease; (4) intertidal marshes has the largest ESV per unit area, followed by mangrove, coral reefs and rocky marine shores, while the marine ecosystem has the smallest ESV per unit area. As proved by the case study, this work can provide a basis for an accounting method for coastal and marine ESV assessment, which could serve to improve both the management decision making processes and policy indications through accurately valuing coastal and marine ES, leading to additional investment in conservation of these ecosystems.

**Keywords**
coastal ecosystem, marine ecosystem, ecosystem services valuation, energy, accounting method.

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**Integrated Optimization Analysis of Urban Food-Energy-Water Nexus Based on Systematic Mathematical Modeling Approach: A Case Study of Beijing**

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**Abstract**
The most essential resources, as food, energy and water (FEW) are strongly interrelated, forming the food-energy-water nexus (FEW nexus) for thriving of urban society. Such a nexus system in urban areas is highly intricate, due to urban areas largely derive FEW resources from those hinterlands, yet the resource-environmental loads often transcend urban administrative borders. However, the great majority of existing studies focused on individually on optimization of FEW resources, which hardly handled the coupled issues of FEW systems and led to a series of issues, such as trade-offs, resource risks, and environmental pollution. Therefore, it is necessary to design and optimize the complex urban FEW nexus for increasing resources efficiency and ensuring the sustainability of the coupled urban-regional areas based on an integrative view.

This paper has proposed a systematic mathematical model to design integrated urban production and consumption systems, which contain the non-linear structure with waste and by-products recycled in the urban system. Cumulative exergy consumption, as a life cycle indicator of resource intensity is adopted to account FEW consumption. The proposed model is applied in Beijing to optimize FEW systems for satisfying its residential and economic demands. The results show that: 1) the total cumulative exergy consumption is estimated to 1830.36 PJ, and the cumulative exergy consumption of FEW subsystems would be at 0.3 PJ, 52.4 PJ, and 1825.30 PJ, respectively; 2) the integrated design indicates that the utilization rates of local resources increase dramatically. For food supply, 42.26% of vegetables and 65.19% of pork demand can be satisfied by local production. For energy, about 8.56% of local new and renewable energy would be used. For water, the reclaimed waste water account for 38.14% of the total water consumption; 3) compared with the silo design, the advantage of the co-design model is significant, which could save 31.41% of resources. For instance, it could reduce 15.09% of the total food consumption, and the share of local food in total food consumption reaches 29.91%. This study presents a systematic model that could capture the integrative options and its results provide some reasonable suggestions to promote resources coordinated management.

**Keywords**
Urban FEW nexus; Integrated optimization; Cumulative exergy consumption; Coordinated management.

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**Natural resource demands and the structural paths of Beijing**

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**Abstract**
The ever-growing demand of human society are related to the consumption of natural resources, which impose pressure on environment. As the nation’s political, cultural and educational center in China, Beijing is one of the region with less resources endowment and large natural resources consumption. Moreover, energy resources are the main consumer goods in Beijing, which has led to serious air pollution. Therefore, the reasonable utilization of natural resources and the reduction of air contamination are critical for the sustainable economic growth. This paper presents a multi-regional input–output analysis and structural path analysis to find the supply chain of embodied natural resources between Beijing and other provinces in interregional transfer to reduce the negative impact on environment. Exergy is used to unify the metric of natural resources input. The total embodied natural resources use (ERU) of Beijing is 1713.48 PJ, while the direct resources input (DR1) is only 155.63 PJ in 2012. Investment is the largest final demand category accounting for 41.1% of the total ERU in Beijing, followed by consumption (37.5%) and export (21.4%). Meanwhile, energy minerals as the main natural resources category contributes 82.7% to Beijing’s consumption, followed by agriculture resources (11.4%), non-energy mineral (3.2%), and other primary energy (0.7). As for interregional trade, Beijing is the net importer of embodied natural resources. Henan, Guangxi, Heilongjiang, Shandong and Anhui are the main agricultural materials suppliers to
Beijing. The embodied energy minerals and embodied non-energy minerals are imported from boundary provinces, such as Inner Mongolia, Shanxi, Hebei, and Liaoning. Guangdong, Inner Mongolia and Yunnan are the important exporters to Beijing's other primary energy consumption. Every province and sector in China have ecological connections with each other, so it is necessary to research on the supply chain of natural resources in regional and sectoral perspective comprehensively. This paper further explores the supply paths with large embodied natural resources flows resulting from the consumption of Beijing. According to the supply chain, energy minerals, non-energy minerals and other primary resources finally contribute to construction industry, and agricultural resources mainly to agriculture and food processing and to tobacco industry in Beijing. This information allows for a targeted policy approach to cleaner production in natural resources and reduce environment impacts of resource use.

In this paper, we focus on the embodied natural resources use and the interregional trade between Beijing and other provinces. The structure of the paper is as follows. A summary introduction of recent studies in embodied resources is presented in Section 1. Section 2 introduces the methodology and data sources in this paper. In section 3, we describe the results of embodied natural resources use in region and sector of Beijing. In the next section, the important embodied natural resources supply paths in the Beijing are further illustrated. Finally, section 5 is the conclusion of the paper.

Keywords
Embodied natural resources, Multi-regional input–output (MRIO) model, Structural paths.

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Composition of dissolved organic matter during coal liquefaction wastewater treatment and its environmental implications
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Abstract
Coal liquefaction can produce liquid fuels and raw materials or chemical products, thus, it is of great industrial significance. However, large volumes of coal liquefaction wastewater (CLW) are produced during this process, which contains dissolved organic matter (DOM) compounds that are harmful to the environment and human health. Therefore, efficiently removing the DOM in CLW is of great environmental significance. Different types of DOM affect the environment differently. Therefore, only evaluating the changes in the DOM content is insufficient, as the content and structural components of DOM directly influence the environmental hazard of CLW. Several advanced processes are currently used for treating coal liquefaction wastewater (CLW) in industrial plants. But the variations in the structural components of dissolved organic matter (DOM) during coal liquefaction wastewater (CLW) treatment are unclear, limiting the further improvement and application of CLW treatment processes. Recently, three-dimensional excitation-emission matrix fluorescence spectroscopy (3DEEM) and ultraviolet-visible spectroscopy (UV-vis) have been widely used to characterize the structural components of DOM. Therefore, in this study, the changes in the composition of DOM and its removal characteristics in CLW and the effluent of air flotation, catalytic oxidation, biofiltration, ozonation, anoxic/oxic (A/O), and membrane bioreactor (MBR) were determined by 3DEEM and UV-vis. Water samples were collected from a full-scale waste water treatment plant (WWTP) in the Inner Mongolia Autonomous Region of China. And the experimental data were analyzed following the fluorescence regional integration (FRI) and parallel factor analysis model (PARAFAC).

The results show that the total organic carbon and chemical oxygen demand of the raw CLW reached 1965.2 and 310.0 mg/L, respectively, with humic acid-like substances as the dominant component (63.1%), and protein-like substances contributing a small amount (5.5%). Air flotation (physical process) could treat humic acid-like substances more effectively, which inhibit active oxygen free radicals. Catalytic oxidation and ozonation (chemical processes) efficiently removed macromolecular aromatic substances with rich fatty chain substituents, thereby reducing the biological toxicity and enhancing the biodegradability of the effluent. The removal of aromatic substances with aliphatic chain substituents during catalytic oxidation was better than that of aromatic substances with oxygen substituents. The DOM removal efficiency of biofiltration and A/O reached 86.6% and 92.3%, respectively. Biological processes can efficiently remove protein-like and fulvic-like substances in DOM, and complex macromolecular substances with a high degree of aromaticity formed simultaneously. After the series of treatment processes, the concentration and environmental hazard of the DOM in the effluent decreased, providing a good basis for discharging wastewater that meets the set water quality standards. The aromatic substances with aliphatic chain substituents were removed more efficiently than those with carbonyl, carboxyl, hydroxyl, and ester substituents. Air flotation laid a good foundation for the subsequent process to proceed smoothly. Based on the different characteristics of the chemical and biological processes, combining these two types of processes achieved efficient and reasonable DOM removal, and improved the removal of DOM by existing treatment processes. So through appropriately combining physical, chemical, and biological processes, the DOM in CLW can be efficiently removed, which demonstrates the improvement and applicability of the existing combined processes.

Following the treatment of CLW by the existing processes, some refractory components remained in the effluent. The residual DOM was macromolecular and non-biodegradable, with a high degree of aromaticity, which could pose a hazard to the environment and human health. Therefore, evaluating and improving the existing processes can provide important guidelines for the further optimization of effluent. Based on the in-depth studies conducted by other researchers, we observed that anammox could better remove highly aromatic macromolecular substances, which can overcome the
limitations of A/O, to a certain extent. Employing anammox can also conserve energy, does not require the addition of a carbon source during treatment, and produces no excess sludge, which has both environmental and economic benefits. However, current research on anammox has been limited to laboratories. We suggest that WWTs should consider improving the existing process and combining it with new processes, such as anammox, to ensure that the processes operate in co-ordination and enhance the DOM removal ability. This would require further research in engineering applications and practical implementation. And metal ions could be added to the CLW treatment process to enhance DOM removal by catalytic oxidation, but the economic and environmental factors should be comprehensively considered in practical application. This study demonstrated that the removal characteristics of DOM with different molecular weights exhibited different environmental hazards. Therefore, it is urgent that the removal characteristics of DOM with different molecular weights during each process are explored. This study could provide a theoretical basis for optimizing the technical parameters and further improving the treatment efficiency of CLW.

Keywords
Coal liquefaction wastewater treatment; dissolved organic matter removal; three-dimensional excitation-emission matrix fluorescence; ultraviolet-visible spectroscopy.

Spinel-structured Mn–Ni Nanosheets for NH₃–SCR of NO with High-resistance to H₂O&SO₂ at Low Temperature
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Abstract
Clean atmosphere is one of the essentials for the beautiful ecological environment and green-to-blue livable cities. Efficient and stable catalysts are of great importance for the purification of gaseous pollutants from industrial flue gases. Nitric oxide (NO) is one of the major pollutants causing retrograde in attending a beautiful ecological environment. The clean technology of selective catalytic reduction (SCR) is considered to be the best technology for the NO removal. Nowadays, low-temperature (LT) selective catalytic reduction (LT-SCR, < 250 °C) is an urgent approach for NOx reduction of exhaust gases from steel, coking and other industries. Mn-based catalysts are widely investigated for LT-SCR due to its various valence states and excellent redox performance at low temperature. However, the inhibition and poisoning effects of H₂O or/and SO₂ are one of the severe challenges.

In this paper, the novel Mn–Ni bi-oxides catalysts with spinel structure and different micro-morphology were prepared by co-precipitation (CP), urea–hydrolysis (UH), co-precipitation hydrothermal–synthesis (CPSH), urea–hydrolysis hydrothermal–synthesis (UHHS) methods, then investigated for NH₃–SCR of NO at low temperature. Various characteristics of XRD, BET, ICP, RAMAN, H₂–TPR, NH₃–TPD, XPS and DRIFTS experiments aimed at elucidating the physicochemical properties, intermediate species, and behavioral effects of H₂O&SO₂ on reaction pathways over numerous Mn-based catalysts during the SCR process. Furthermore, the Mn-based catalysts with good resistances to H₂O&SO₂ were successfully synthesized with special structure and morphology by improving the synthesis methods.

It was found that Mn(2)Ni(1)Ox (molar ratio) catalyst prepared by co-precipitation method performed excellent low-temperature SCR activity and good resistance to SO₂, which obtained above 80% NOx conversions within 15 hours in the presence of 150 ppm SO₂ at 175 °C. The main reasons for excellent SCR activity were due to the special spinel structure with the alternate tetrahedrons and octahedrons, and the efficient electronic interaction of different valence state such as Mn⁺⁴-Ni⁺⁴↔Mn⁺²⁺Ni⁺². The essential reaction pathways based on ER mechanism were less affected by the competitive adsorption with SO₂, which was deemed as one of the major reasons for good SO₂-resistance.

The optimum molar ratio of Mn:Ni (M:N) and urea/(Mn+Ni) (u:M) were determined using UH, so also, the suitable hydrothermal temperature (150 °C), time (24 h), and further calcination (450 °C for 6 h). Furthermore, the NiMnO₄ nanosheet with different morphologies were investigated. The arch-structure catalysts were prepared using UHCP and foliated NiMnO₂ nanosheets with more uniformity, high surface area and little pore size were successfully synthesized by the combined methods of hydrothermal synthesis with co-precipitation and urea–hydrolysis, respectively. The XRD and SEM results showed that the Mn(2)Ni(1)Ox–UHCP catalyst obtained pure MnO₂Na₄ nanosheets–phase nanosheet than the Mn(2)Ni(1)Ox–UH. Both the two catalysts had high-efficient SCR activity (>98% NOx conversion at 100–250 °C) and N₂ selectivity (>99% at <150 °C and >85% at <250 °C).

The uniform nanosheet NiMnO₂ nanosheete prepared by UHHS method obtained an outstanding low-temperature activity and excellent resistance to H₂O and SO₂, which obtained 85~90% NOx conversion in the presence of 10 vol.% H₂O and 150 ppm SO₂ at 150 to 300 °C. Based on the BET, TPD, TPR, XPS and DRIFTS spectra, the main reasons for excellent SCR activity and resistances were due to the spinel structure with an outside configuration of tetrahedrons embed by Ni sites which avoided the sulfation of inside octahedrons wrapped Mn active sites, the foliated nanosheet morphology which retarded the adsorption of sulfur ammonia species resulting in the remission of deposition/inhibition effects, and the efficient electronic interaction (Mn⁺⁴+Ni⁺⁴↔Mn⁺²⁺+Ni⁺²). Besides, the reaction pathways based on ER mechanism were...
less affected by the competitive adsorption with SO₂, which was one of the major reasons for good SO₂-resistance.

Keywords
Mn–Ni spinel; nanosheet; urea–hydrolysis; hydrothermal–synthesis; selective catalytic reduction; resistance.

A Systematic Literature Review of Circular Economy Indicators for Supply Chains
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Abstract
The increasing interest of policy-makers in promoting the development of sustainable production and consumption systems has already shaped legislation and directives globally; many nations are embracing a Circular Economy (CE) strategy to become less wasteful in their approach to resources. Such recent developments highlight the necessity to develop measurement systems that are able to keep track of this transition at different levels. The People’s Republic of China, with its 2008 Circular Economy Promotion Law, has been the first country to develop CE indicators at a national level (Geng et al., 2012). Also in the European context, closing the loop of products and material flows is considered a key strategy in many industries, in order to decouple growth from resource consumption (European Commission, 2015 and 2018). In this context, both the academic and the business communities widely recognise that supply chains have a very important role as the key unit of action in order to put Circular Economy principles in practice (Ellen MacArthur Foundation, 2013; Aminoff & Kettunen, 2016; Govindan & Hasanagic, 2018; Batista et al., 2018). Also, recent pieces of legislation promoted by the European Union, such as the Circular Economy Package (European Commission, 2015) and the Circular Economy Action Plan (European Commission, 2018), recognise an important role for existing organisations, which, through bottom-up initiatives, can contribute to realise the transition towards Circular Economy in a free-market economic scenario. It is clear that, in order to improve the global net sustainability of a product, it is necessary to go beyond the organisational boundaries, developing a holistic understanding of the impacts across the supply chain (Koh et al., 2013; Genovese et al., 2014) and taking a systemic view on social aspects as well (Rajeev et al., 2017). However, developing multi-objective performance measurement systems with such an inter-organisational approach is challenging, especially considering the dimension and the complexity of supply chains in modern markets, which involve many actors across different geographical contexts (Genovese et al., 2017).

Despite the acknowledged need for developing supply chain perspectives aimed at driving the transition towards the Circular Economy, many academics agree that a better understanding of the managerial aspects of Circular Economy is still required (Genovese et al., 2017; Batista et al., 2018). Many organisations are implementing Circular Economy practices across their supply chains emphasising product and material reuse and recycle, increasing the level of re-generativity of their production and consumption systems, also integrating the use of renewable energy sources throughout supply chains (Genovese et al., 2017). However, there are not established measurement approaches to help practitioners and policy makers to keep track of the effectiveness of these Circular Economy interventions and to measure the resulting degree of circularity of supply chains.

This study aims at identifying and classifying indicators which have been developed in order to measure, in a rigorous way, the transition towards the Circular Economy in a supply chain context, and for recognising the potential of supply chains to benefit from Circular Economy interventions. The final objective of the analysis is to build a taxonomy of all the metrics that have been employed, according to the economic, environmental and social dimensions, in order to create a complete overview of the indicators that have been mentioned at least once in the literature.

The study will be conducted with the method of systematic literature review, which is considered a useful method for locating, selecting, analysing, appraising and evaluating the body of knowledge which is relevant to a particular research question (Denyer & Tranfield, 2009), and which has been extensively used both Supply Chain Management (Cerchione et al., 2018; Centobelli et al., 2017) and Circular Economy (Govindan & Hasanagic, 2018; Merli et al., 2018) fields of study.

In order to identify all the relevant contributions, both the academic and the grey literature (the latter being concerned with both national and international business and policy organizations scientific reports) will be considered. The combination of keywords that have been used in the source selection phase, included also Closed Loop Supply Chain and Industrial Ecology and Reverse Logistics keywords. Such contributions offer relevant insights, in terms of taking a life-cycle perspective of products and material flows, and of considering all the phases from the extraction of raw materials to the product’s end-of-life. More recent contributions, coming both from academic research and from international think-tanks publications (see, for instance, reports produced by Ellen MacArthur Foundation in 2015 and World Business Council for Sustainable Development in 2019), are focusing on defining specific metrics and indicators for circularity (Saidani et al., 2019). Such measurement systems strive not only to measure the negative environmental impact of production systems, but also to assess the extent to which a supply chain is able to reduce its waste streams through various interventions. In a closed loop system, indeed, products and materials are recovered before becoming waste (Genovese et al., 2017) and resources are kept in use (Franklin-Johnson et al., 2016).

A further intention is also to assess when these metrics have been employed in real industrial settings and tested on primary data, in order to measure the impact of Circular Economy practices adoption in specific sectors. It is indeed agreed that general and descriptive models, along with numerical examples devoid of real-world implications might not be able to meet the precise needs of single sectors and actual industry challenges (Kazemi et al., 2018).
Key findings of this study will include the identification of a restricted set of key performance indicators, which could be utilised by practitioners and policy makers for keeping track of the effectiveness of Circular Economy interventions at a supply chain level.

Keywords
Circular Economy Indicators, Circular Supply Chain, Supply Chain Management, Performance Assessment, Systematic Literature Review.

Molecular-level characterization of stratified extracellular polymeric substances of the Anammox sludge and its role in dissolved organic matter removal
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Abstract
Anaerobic ammonium oxidation (Anammox) is a novel and efficient alternative to traditional nitrogen removal processes. Previous studies mainly concentrated on investigating inorganic nitrogen removal and improving the Anammox process' performance (Yang et al., 2010; Zhang et al., 2011). However, the performance of organic matter (DOM) treatment by this process has always ignored, which restricts its development. Extracellular polymeric substances (EPS) exhibit clear hydrophobic properties, and that they are responsible for adsorption as they provide some sites for the sorption of dissolved organic compounds (Sheng et al., 2010). However, there are little data regarding the changes in the molecular composition of DOM during Anammox, and the behavior of DOM between the aqueous solution and EPS, particularly in the stratified EPS from the Anammox sludge. Fourier-transform ion cyclotron resonance mass spectrometry (FTICR-MS) can provide detailed information regarding the elemental compositions of a complex mixture at a molecular level (Phungsai et al., 2016), and some useful information for understanding transformation pathways and removal preferences during treatment can be exhibited by the molecular-level elemental compositions of DOM.

The obtained results in this study show that the influent TN and TOC concentration during the Anammox process were 150-187mg/L and 143-150mg/L, respectively, with the TOC removal efficiency varied between 45% and 58%. With respect to the contribution of each component to DOM in the wastewater before and after the Anammox process, S:N heteroatoms containing formulas accounted for around 77%-62%, depending on the calculation of the formulas or by summatng the normalized intensities. The removed CHO compounds were mainly distributed in the relatively higher H/C and lower O/C region, while the newly formed ones accumulated in the lower H/C and higher O/C region, indicating the more bio-resistance of CHO molecules after the Anammox treatment. With respect to CHON compounds, one N atom formulas were predominant (42.3%) in this study, followed by two, three and four N atoms (27.7%, 21.0% and 6.7%, respectively). The CHON compounds with relatively low O/C ratio were preferentially removed.

The molecular characterization of the stratified EPS from the Anammox sludge was also carried out. The average molecular weights (MWWwa) for slime, LB-EPS, and TB-EPS were 388Da, 340Da, and 364Da, respectively. The CHON compounds are the substantial part of DOM in Anammox EPS. A higher abundance of unsaturated and oxygenated groups (such as -COOH, -OCH3, -OH) existed on the surface of the Anammox sludge. This not only gave birth to the more formulas on the slime layer, but also indirectly reflected the greater adsorptive ability than the bound EPS. Besides, lignin-like compounds were the predominant component for the CHO and CHON molecules in the three Anammox EPS layers, followed by protein and tannin compounds. With respect to CHOS and CHONS formulas, lignin-like and protein-like compounds were the major components, followed by tannin and carbohydrates compounds. The relatively lower proportion of protein and carbohydrates fractions in slime and LB-EPS layers implied their higher dewatering ability compared with the TB-EPS of the Anammox granular. Furthermore, 35.8%, 26.6% and 9.5% of all the removed compounds in the wastewater were attributed to the adsorption by slime, LB-EPS and TB-EPS, respectively. This phenomenon reflected the outer layers might have a greater adsorptive ability for organics than the TB-EPS layer from the sludge. The number of produced molecular formulas was 1695, of which 35.4%, 16.1% and 13.4% were originated from slime, LB-EPS and TB-EPS, respectively. The slime layer seemed to contribute greatly to the refractory nature of the effluent. They were likely associated with the biochemical transformation in the Anammox process and therefore, the performance of the reactor. The common and compositionally linked molecular formulas occurred at lower masses (mass <350Da accounting for 74.87%), and 93.4% of the total common ones were also detected in the resistant component of the wastewater in the reactor. Therefore, it is imperative to carry out effective method to deal with this common DOM, which was characterized with low MW and relatively higher reductive degree, lower oxidizing degree.

Abstract
Fourier-transform ion cyclotron resonance; dissolved organic matter; Anammox; extracellular polymeric substances.

Features and evolution of global net fossil energy flow networks: from the exergy perspective
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Abstract

Fossil fuels play a significant role in economy, usually containing available work and waste. It is the available work provided by fossil fuels, i.e., exergy, that each country really needs. An exergy flow network is embodied in the global fossil energy trade each year. With many countries both importing and exporting fossil fuels, it is necessary to understand the net exergy flow pattern in the international trade. In this paper, we converted the total trade volume of crude oil, coal, LNG and CNG into exergy and constructed global net fossil energy exergy flow networks from 2000 to 2017, with countries as nodes and the net exergy flows as the edges. We found that most countries are either exergy suppliers or demanders, whereas a few of them are transit countries. The main exergy flow paths are very short, flowing directly from the original exporters to the final importers or basically through one or two countries as mediators. In general, on the global level, the Middle East is the source of exergy flow, and the USA and Europe are the two main destinations. On the regional level, there are two regional exergy flow communities: CIS and the Asia-Pacific region.

Keywords

exergy flow; fossil fuels; international trade; complex network.

Quantitative evaluation of live sheep transportation cost and carbon emission under different paths

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Abstract

The live sheep supply model of “farmers-intermediaries-slaughterhouses” is widely distributed in various regions of China. Due to the lack of unified and standardized management, it shows the characteristics of high transportation cost and large energy consumption, and energy consumption is the most important cause of the increase of carbon emissions. Therefore, it is necessary to further strengthen the research on the optimization method of live sheep transportation.

In order to reduce the cost and energy consumption of live sheep transportation, improve supply efficiency, and gradually realize the sustainable development of the meat sheep industry. This paper takes the live sheep supply model of “farmer-intermediary-slaughterhouse” as the research basis, and systematically analyzes the influencing factors, cost types and energy consumption types of the cost and energy consumption during the transportation process of live sheep. Based on the actual problems and actual needs, this paper improves the calibration problem of genetic algorithm and improves the group diversification problem, and uses the improved genetic algorithm to optimize the transportation path of live sheep. This paper establishes a quantitative evaluation model of cost and carbon emissions during the transportation of live sheep (The cost types include vehicle depreciation cost, vehicle fuel power cost, vehicle tire depreciation cost, vehicle maintenance and insurance cost, transportation link labor cost, vehicle operation management cost, loading and unloading labor cost, live sheep quality loss cost and consumable cost. Aspect; energy consumption types include electrical energy and vehicle fuel consumption) and demonstrates it as a specific implementation case in 10 townships (supply points) in Chaoyang City, Liaoning Province.

The results show that: (1) The improved genetic algorithm can effectively search for the optimal path, that is, the simulated distances of the random path, the suboptimal path and the optimal path are 384.2km, 427.7km and 391.8km respectively, and the corresponding actual route distances are 798.5km, 601.2km and 512.9km respectively. The route distance of the optimal path is reduced by 244.6km from the route distance of the random path. The correlation distance between the simulated distance and the route distance corresponding to the random path, the suboptimal path and the optimal path is 0.7750 and the highest is 0.9041, which is highly correlated and satisfies the research reliability. (2) Optimal path cost distribution: vehicle fuel power cost accounted for 23.5% of total cost, transportation link labor cost accounted for 15.3% of total cost, vehicle maintenance and insurance cost accounted for 13.6% of total cost, and vehicle depreciation cost accounted for 12.9% of total cost. The cost of consumables accounts for 12.6% of the total cost, the labor cost of loading and unloading accounts for 10.6% of the total cost, the cost of live sheep loses 5.8% of the total cost, the cost of vehicle operation and management accounts for 3.7% of the total cost, and the depreciation cost of vehicle tires 3.5% of the total cost. (3) Comparing the calculation results of the cost or energy consumption of the random path, the suboptimal path and the optimal path, it can be seen that the cost of each type of the optimal path is the lowest. The total cost of the optimal path is 432 yuan less than the total cost of the suboptimal path, and the total cost is reduced by 9.8%. The total cost of the optimal path is reduced by 1,445 yuan compared to the total cost of the random path, and the total cost is reduced by 26.5%. The total carbon dioxide emissions of the optimal path are 16kg lower than the total carbon dioxide emissions of the suboptimal path, and the total carbon dioxide emissions are reduced by 8.6%. The total carbon dioxide emissions from the optimal path are reduced by 219 kg compared to the total carbon dioxide emissions from the random path, and the total carbon dioxide emissions are reduced by 36.3%.

The high cost of live sheep transportation and the large energy consumption are the key issues affecting the sustainable development of the meat sheep industry. But there are few studies on the sustainability of live sheep transportation. This study can provide a theoretical reference for the optimization and measurement of live sheep transportation in different regions of China.

Keywords

live sheep; cost; carbon emission; energy consumption; transportation path; evaluation model
NO selective reduction by CO with excess oxygen over WO3-SiO2 supported Ir-based catalysts
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Abstract
The clean purification technique for selective catalytic reduction of NO by CO (CO-SCR, De-NO) is regarded as the desired method for the simultaneous abatement of nitric oxide (NO) and carbon monoxide (CO) in the flue gases from industrial factories.

NO which is one of the major air pollutants from flue gases considerably contribute to the cause of several environmental issues, such as acid rain, ozone depletion, greenhouse effects, and photochemical smog. In recent years, selective catalytic reduction of NO by ammonia (NH3-SCR) technology has been demonstrated to be the most effective method for NO removal. However, this technology has several limitations including NH3 leakage, catalysts poison, pipeline corrosion and blockages, and adding extra reducing agents. A potential method that is catalytic reduction NO by CO has been the attentions of several stationary industrial factories such as coking, sintering and steel plants, where CO is readily available as a byproduct.

Taster and Murrell (1976) confirmed that the feasibility of selective catalytic reduction NO by CO with noble metal catalyst, which was the first report about CO-SCR reaction in 1976. Then, the researchers demonstrated that the noble metal iridium (Ir) was a promising catalytically active species for NO reduction with CO. Ogura (2000) investigated the effect of different single component carrier on Ir-based catalysts and found that Ir/silicalite catalyst has relatively high catalytic activity (80%) at 365 oC. Wang (2003) reported that Ir/Zeolite-5 was effective for NO reduction with CO under lean conditions. Yoshinari (2003) and Haneda (2005) showed that Ir/VO, and Ir/SiO2 catalysts had activity for NO reduction by CO, especially Ir/WO, catalyst has better reaction performance. However, the low specific surface area characteristic of WO3 largely limited the catalytic activity. More and more research results on selective catalytic reduction NO by CO have been reported, however, this method has not executed in industry application since flue gases have excess oxygen (O2) suppressed NO reduction efficiency.

In this study, Ir-based catalysts supported on co-synthesized WO3-SiO2 were prepared by ultrasonic-assisted equal-volume impregnation and investigated for CO-SCR activities including NO conversion and CO conversion in the presence of O2 (0–15%).

The experimental results showed the sequence for NO conversion at 200-300 oC was followed as Ir/WO3 > Ir/SiO2 > Ir/Al2O3 > Ir/TiO2, which was benefited from the existence of Iro species and the strong interaction of Ir-W(Si) during CO-SCR process, considering the XRD and H2-TPR results, while IrO2 species might be in favor of the simultaneous oxidation of both CO and NO. Furthermore, Ir/VO3-SiO2 catalysts with different W/Si molar ratio were investigated for CO-SCR of NO, in which Ir/VO3/SiO2 catalyst exhibited the most effective activity for NO reduction of 49% and CO oxidation above 98% at 250 oC ([NO] = 500 ppm, [CO] = 1000 ppm, [O2] = 15 vol%, N2 balance, GHSV = 32,000 h-1). Characterization of XRD, H2-TPR, RAMAN, FTIR and XPS results confirmed the active sites of Iro species and synergistic effects with supporters of W and Si bi-oxides with strong redox property.

The effects of water and SO2 on the CO-SCR performance over optimized 2 wt% Ir/VO3-SiO2 were also examined. The results presented that water affected the interaction between WO3 and SiO2, resulting in decreased activity, while SO2 promoted the CO-SCR activity due to the inhibition process of Iro-species oxidation. The material with further optimization will be expected to be industrial application for simultaneous removal of NO and CO without extra reducing agents.

Keywords
Ir/WO3-SiO2; Selective Catalytic Reduction (SCR); NO; CO; Excess Oxygen;

Achieving sustainability through efficiency: A survey of advances in and promotion of cleaner production in the oil and gas sector
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Abstract
Sustainability, understood as the ability to be maintained over time (Kuhlman and Farrington 2010), has been a dominant policy theme since the turn of the twentieth century. Sustainability as a concept has gone beyond its theoretical assumptions making inroads into practice of governments, corporations and communities. Owing to its extractive credentials, oil and gas sector has been a peculiar case of the matter in support of the concept including due to the impact of economics of renewable resources (Helm 2017).

Drawing on the conceptual and empirical material this paper aims at surveying advances in and promotion of cleaner
production in the oil and gas sector. Data and evidence has been collected using relevant academic and industry sources to understand the extent to which internalization of sustainability through efficiency has taken place. Examples of relevant industry practices have been collected to present the most up-to-date state of play at a critical policy juncture whereby the energy-climate nexus becomes stated priority of governments, and non-governmental entities, international organizations, and businesses around the world.

With its Triple Bottom Line (Ellington 2018) approach encapsulating the people, economy and the environment sustainability provided for a discursive approach to study specific cases of the matter while providing both a framework for analysis and, at the same time, contestation of a degree of usefulness of the very approach. The peculiarity of the oil and gas industry as part of the sustainability discourse, or more broadly the Circular Economy (Geissdoerfer et al. 2017), has been the fact that the industry has been seen as being either part of the problem or the solution. All of this has led to obscure a picture as to how the sector can be accommodated through sustainability discourse owing to the extractive nature of the business and the role it plays as the primary supplier of fossil fuels which, at the same time, are responsible for greenhouse gas emissions and depletion of the resources.

Having in mind contested nature of the problem the paper takes on board efficiency as a measure to discuss ways in which the oil and gas sector has been working to change the business as usual while contributing towards a broadly defined transition of the energy sector.

Keywords
sustainability, efficiency, oil and gas.

Urban dietary changes and linked carbon footprint in China: A case study of Beijing
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Abstract
Rapidly rising wealth and increased urbanization are driving a global urban dietary transition, which is closely related to global climate change and human health. In light of large urban population, preference for fine foods, and serious environmental challenges, such trends are particularly important for China. This study investigated urban dietary changes of Beijing during 1980–2015, and quantified the urban diet-related carbon footprint (CF) from the life cycle perspective. A deviation model was developed to evaluate urban dietary quality. Results showed that the traditional grain-based diet in Beijing was replaced by the one higher in non-staple and animal-sourced foods. The diet-related CF increased by 41% from 2.15 in 1980 to 3.04 kg CO2-eq in 2015 per capita per day, mainly due to the rising consumption of animal products. In Particular, the unnecessary CF owing to over-consumption of food accounted for 15–31% of the total CF. Correspondingly, the connection between environmental impact and urban dietary quality changed from trade-offs to synergies over time. These findings highlight the urgent need for integrated policy interventions, from both the production and consumption sides. Especially, the synergy trend indicates the opportunity of reducing the adverse impacts of urban diet on the environment and human health, through shifting toward a healthy dietary pattern.

Keywords
urbanization; dietary changes; carbon footprint; food policy.

System dynamics modeling for materials demand and environmental impact of urban residential buildings: A case study of Beijing, China
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Abstract
Intensive erection and replacement of building stock is one of the natural characteristics and results of rapid urbanization, which is particularly evident in China. Such process requires enormous amounts of construction materials and induces a series of resource and environmental problems, which deserves more attention paid to it from viewpoint of flow and stock dynamics. Construction material stocks accumulating in buildings play a fundamental but underappreciated role in shaping the use of material and energy resources. Configuration and quantity of building stocks has very close relevance with waste flows and recycling potential and is key to closing material loops and reducing waste and emissions in a circular economy (Krausmann et al., 2017). Whether cities can develop towards sustainability largely depends upon the way in which they manage their material stock and flow (Kennedy et al, 2015). Additionally, existing studies were also carried out dominantly on country level, while city scaled analyses are relatively insufficient.

Stella is an software for graphic and dynamic simulation, which is widely in system dynamics models. The use of iconographic modelling techniques makes the model a flexible simulation tool with an easy user interface for making
change and calibrate. It offers a flexible way to dynamically visualize and communicate how complex systems and ideas really work by building a variety of simulation models from causal loops or stock and flow (Isee System, 2006), which greatly improves the interaction and generality of modeling. The modeling paradigm with stock and flow makes Stella particularly suitable for dynamic material flow analysis. In addition, the scenario analysis can also be easily conducted without the need to write complex program code.

In this paper, a system dynamics model was developed using STELLA platform to model the urban residential building changes and related materials demand, CO2 emission and construction and demolition waste (CDW) for the City of Beijing over 1949–2060. Results show that the stock and flow of residential building in Beijing present diversified change trends under different scenarios with regard to building life-time and residential life style. For the baseline scenario, the construction flow peaked in 2005 and the stock will saturate around 2060 with total building floor area of 3.98E+8m2. From the resource-environmental point of view, an overall drop in material and CO2 emissions for new building construction over the next years can be founded for middle and long lifetime scenarios, while for short lifetime scenario current trend continues. For all the scenarios, Beijing city will face with great challenge of disposing CDW of residential building at the later part of this century. The results obtained in this work highlight the great need of effective policy intervention as prolonging service lifetime of buildings and strengthening recycling practice as well as planning waste treatment facility in advance to promote sustainability of urban residential development.

**Keywords**
system dynamics model; urban residential buildings; stock-flow; STELLA

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**Life Cycle Assessment and Ecological Footprint Analysis of Various Clean Energy Power Generation modes**

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**Abstract**

With the rapid development of economy, developing renewable and clean energy instead of fossil energy has become a main trend in order to alleviate accelerated deterioration of the environment and energy crisis. Wind power, solar photovoltaic and biomass power generation have been developed rapidly with cleaner production.

Are these so-called clean energy really clean? In order to quantitatively analyze the economic and environmental benefits in the life cycle of wind power, solar photovoltaic and biomass power generation technologies, a complete LCA accounting system is established according to a series of standards issued by ISO on LCA. Furthermore, taking Fanggang Wind Power Generation Project, Asi Photovoltaic Power Generation Project and Shangcai Biomass Power Generation Project as typical cases, environmental impact and carbon footprint analysis are carried out. Finally, Reasonable suggestions are put forward for the cleaner energy power generation.

The results show that (1) the energy consumption of wind power generation is the smallest among these three power generation technologies, only 6.800 kJ/kWh, and its environmental impact potential are the lowest. Therefore, its ecological footprint is also very small, only 0.002 m2/kWh. (2) the highest energy consumption occur in solar photovoltaic power generation among these three power generation technologies, up to 228,343 kJ/kWh, and its acidification potential, human health potential and photochemical potential are the highest among these three technologies, while its ecological footprint locate in the middle. 4.441 m2/kWh. (3) global warming potential and water rich oxidation potential of biomass power generation are the largest among these three power generation technologies, namely 3949.184 g/kWh and 9.062 g/kWh, respectively. And its ecological footprint is 5.799 m2. (4) the cost of generating 1 kWh for photovoltaic power plants and wind power plants is 0.31 yuan, and the cost of biomass power generation 1 kWh is only 0.05 yuan.

In summary, if only cost is considered, biomass power generation is the most economical way to generate electricity. However, wind power generation is currently the most developed clean energy generation method.

**Keywords**

wind power generation; solar photovoltaic power generation; biomass power generation; life cycle assessment; ecological footprint.

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**CO2 Emission and human development in Chinese cites**

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Abstract

As engines of economic development, cities are major contributors to energy consumption and CO₂ emissions, as well as being leading innovators and implementers of policy measures in sustainable development. The sustainable development roadmaps in cities has been raised special attentions. As a reference metric to quantify one region’s socio-economic development, the human development index (HDI) focuses on three dimensions, including health, education and income rather than economic growth alone. Thus, HDI shows its superiority in measuring the country’s development and progress from the perspectives of people and their opportunities. The indicator can be conducive to understanding city’s development stage and supporting authorities’ decision-making, while the measurements are taken at the detailed levels. The HDI of Chinese cities has not been well researched, mainly owing to the lack of systematic statistics and poor data quality. Focusing on this research gap, we develop a framework to calculate city-level HDI in China based on the widely used HDI calculation methods for countries. The newly proposed HDI is compiled in terms of the definition provided by the UNDP approach and covers three indexes (Life Expectancy Index, Education Index and Income Index), and four indicators (life expectancy at birth, mean years of schooling, expected years of schooling and gross national income per capita). We then apply the new framework to 326 Chinese cities for HDI accounts and discuss the cities’ development pathways from the view of industrialization. The CO₂ emission in cities are also linked and explored. Understanding diversity in development pathways and associated environmental cost of cities is the basis for city sustainable development policymaking and research in the future.

Keywords

Human development index (HDI); CO₂ emission; City; Industrialization; Sustainable development.

A Review of the Penetration of Sustainability Criteria in Closed-Loop Supply Chain Network Design Problems

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Abstract

Recently, growing concerns have been raised about the environmental and social impact of industrial production and business operations. The increasing consumption of limited natural resources and usage of disposal capacities has placed a lot of emphasis on waste management issues. Within this context, a new economic paradigm started spreading worldwide, which is defined as “Circular Economy”. The Circular Economy (CE) is concerned with the reduction of the environment as a sink for discarded products, and with the manufacturing of self-sustaining products, which can be effectively reutilised, remanufactured and from which materials can be easily extracted for recycling at the end of its useful life.

As such, within supply chains, companies have become aware of the importance of product returns and remanufacturing policies in order to try to reduce their materials consumption and to preserve non-renewable resources as well as land usage for the future generations. Consequently, supply chain issues, especially green, reverse and closed-loop supply chain (CLSC) management, have become very popular topics for researchers (Hajiaghaie-Keshhti, 2018; Zhen et al., 2019). This trend has also been inspired by the growing concern about poverty, climate change issues, and need for social development (Brandenburg et al., 2014).

CLSCs consist of both a traditional forward supply chain (from raw materials extraction to product manufacturing, sale and usage), in addition to a reverse network element which collects products from end-users, and then provides several options for extending its useful life, such as remanufacturing, recycling, refurbishing, repairing (Govindan et al., 2015). The popularity of these subjects in the academic community has given rise to the development of a number of publications in the literature over the last several years; the number of papers is still rising as also mentioned in review papers from (Souza, 2012; Govindan et al, 2013; Kazemi et al, 2018).

One of the most critical issues in closed-loop supply chain management is the explicit consideration of sustainability criteria into models and methods for addressing network design problems. As such, environmental (such as CO₂ emissions, fuel consumption, energy usage) and social impacts (such as new job opportunities, fair labour policies and contributions to the local communities) should be taken into account besides economic viability (Zhalechian et al, 2016) when designing CLSCs.

This research presents a systematic literature review of works focusing on closed-loop supply chain (CLSC) design problems, evaluating the coverage of the different sustainability dimensions within such a field of study. Our paper aims at identifying economic, environmental and social indicators that are used to measure and optimise the performance of CLSCs; such indicators are then categorised and classified. To this aim, a careful scrutiny of the identified body of literature is performed. Also, a classification of the employed mathematical models and solution methods is developed, along with a survey on the applicability of the developed approaches to real-world cases and to different types of supply chains (for instance, Dyad, Triad and Myriad configurations).

One of the major gaps identified in the existing body of knowledge is the fact that, while the integration of economic and environmental considerations is emerging, social criteria are still scarcely studied. Indeed, to the best of our knowledge,
only a few articles considered economic, environmental, and social dimensions, simultaneously. While CLSCs seem to be intuitively offering environmental advantages, the explicit measurement of their wider sustainability performance (also taking into account the social dimension) is often overlooked in the current literature (Souza, 2012; Govindan et al, 2015; Kazemi et al, 2018). Indeed, while most of the models and methods for CLSC design problems are based on economic performance measures and constraints (with some attention to environmental issues), there has been less attention being paid to social criteria assessment (Moreno-Camacho et al., 2019). As such, the paper also develops some practical suggestions about the possible simultaneous integration of the three sustainability dimensions CLSCs design problems.

Keywords
Circular Economy, Closed-loop Supply Chain, Sustainability, Supply Chain Network Design, Systematic Literature Review.

Analyzes of Energy Recovery based on small scale solutions of WtE for small and very small municipalities in Brazil
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Abstract
INTRODUCTION: Growing attention to Municipal Solid Waste (MSW) management has promoted several options for recycling, recovery, and treatment of residues. Many developed countries, especially in Europe, already have waste management systems in place to promote these options, particularly to exploit their potential for energy recovery (European Parliament and Council, 2008), aiming a more sustainable economy by effective use of resources, such as waste. In Brazil, the National Solid Waste Policy (PNRS), established in 2010, provides a set of guidelines and path to residues treatment and disposal, adopting as principal the shared responsibility for waste generation, management, and disposal. In regard to energy recovery from MSW, the PNRS allows it but not without reservations such as the mandatory implementation of an emission monitoring system that must be recognized and approved by local environmental agencies, especially for Waste to Energy (WtE) plants based on thermal processes (Brasil, 2015a). The PNRS also establishes goals for all municipalities in the country. Small municipalities with population bellow 50 thousand inhabitants must end waste dumping and define a proper approach to manage, treat, and dispose residues until July 2021. Municipalities with larger population between 50 and 100 thousand must meet the target until July 2020 and municipalities with more than 100 thousand inhabitants until July 2019 (Brasil, 2015b). The reason to define different terms depending on the number of inhabitants of a municipality indicates the influence of this variable on the municipalities waste management conditions. Thus, the processes to adopt all Brazilian municipalities to the PNRS guidelines depend directly on the capability of each municipality to plan and manage their own approach to deal with solid waste. The study objective was to identify variables influencing the WtE technology adoption in small and very small municipalities in Brazil. The study methodology evolved a literature review based on Archival Research Method (Sanches-Pereira et al., 2016) and case study, using Brazil, because it orients the study towards a better understanding of a phenomenon in the real context, providing basis for a better decision-making process (Yin, 2014).

RESULTS & ANALYSIS: Brazil is a vast country, which contains 5,570 municipalities and a population of approximately, 208 million people spread out in 27 states (IBGE, 2019). In general, Brazilian municipalities have a significant portion of population in the urban area, concentrated mainly in the South and Southeast region, where is also concentrated the technologies for energy recovery from MSW, and which contains the majority of the country’s population living in large municipalities and is the most developed. Municipalities with less than 50,000 inhabitants are considered small and very small and correspond to approximately 88% (4,904) of Brazilian municipalities, accounting for 37% of Brazilian population. Thus, it is important to consider their particularities to improve decisions towards more efficient public policies fostering WtE applications. Since the PNRS came into force in 2010, until 2017, less than half (i.e. 49.65%) of municipalities completed their municipal sanitation plans, which allowed them to have access to governmental resources for improving their solid waste management and/or local infrastructure. The remaining municipalities (e.g. 50.35%) are in the process of developing it, from which the majority correspond to small municipalities with population bellow 50 thousand inhabitants (MMA, 2017). With regards to the actual MSW scenario, the PNRS indicates a path to reduce, recycle, recovery and treat residues, but most MSW destination is still based on landfilling or discarding into dumpsites. Besides that, the most common adopted WtE technology is landfill biogas capture. Nowadays, there are currently 2,064 operating landfills, from which only 61 adopted biogas capture projects for WtE (ANEEL, 2018; UNFCCC, 2017; CIBIOGAS, 2019, CNM, 2017). Despite increasing the number of WtE projects and improving waste management of several municipalities, the PNRS presents a challenge for small and very small municipalities because it disregards technical, economical, territorial, and environmental variables. Kumar and Sanniader (2014) utilized a systematic approach to list several aspects and define the necessary requirements for effective energy recovery from waste, and in between the aspects considered were: challenges associated with developed and developing countries, and environmental and health impacts of WTE facilities, for example. Also, they indicated the relation between the amount of the waste generated and the Gross Domestic Product (GDP), which is proportional. Rentziales et al (2014) observed that wealth, economic and technical parameters, for example, also affect the path through the definition of waste management methodology in each locality. With respect to the technology, when it is
(i) adaptive to the amount of residues generated in a municipality, (ii) does not demand a complex waste segregation, (iii)
causes low impact on the environment, and (iv) is feasible for a municipality or a consortium of municipalities (Dalmo et
al., 2019), has higher chances of success and to compete with landfilling solutions. In this sense the analyses identified at
least one parameter for territorial, technical, social, economic and environmental variables to be considered on WtE
adoption in Brazil, focusing on small and very small municipalities.

CONCLUDING REMARKS: The study concludes that the number of inhabitants do not constitutes the only variable
which influences WtE adoption in small and very small municipalities in the country. Therefore, at least one parameter was
defined for territorial, technical, social, economic and environmental variables with the aim to support WtE adoption
analyzes and facilitate public policies decisions on waste management and disposal, considering the energy recovery from
waste solution. For further studies its recommended to evaluate scenarios containing different municipalities, considering
the parameters and suggesting WtE solutions based on the parameters, to test correlation between the parameters
identified and the feasibility of the WtE solution.

Keywords
Waste management, energy recovery, WtE, Brazil, small municipalities.

The relationship between environmental performance and financial performance: A review
toward variables measurement and data resources
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Abstract
Now global environmental is a serious problem all over the world. Firms make more contribution to this problem. Firms
are more facing this problem for social responsibility (Jose F. Molina et al. 2018). Although the existing body of empirical
literature on the relationship between corporate environmental performance (CEP) and corporate financial performance
(CFP) is continuously growing, the relationship between corporate environmental performance (CEP) and corporate
financial performance (CFP) constitutes one of the most puzzling phenomena pertaining to research on organizations and
the natural environment.

The increased environmental concern make the company reduce environmental pollution through pro-active ways (Porter
& Reinhardt, 2007; Ki-Hoon lee & Byung Min, 2018). From the resource-based review, firms need to improve financial
performance through improve environmental performance, such as reduce the carbon emission and other pollutions
(Carmen et al., 2018; Fortune Ganda & Khazamula Samson Milondon, 2018; Yu He et al., 2017; Isabel et al., 2015; Hidemichi
Fuji et al. 2013; Iwata & Okada, 2011), improve corporate environmental management system, and used friendly environ-
mentally activities and strategies leading to materials more efficiency (Menguc & Oztanne, 2005; Orlitzky et al.,2003; Lee &
Min, 2014).

Drawing on different variables had measured in the previous studies. Most of these papers measured financial performance
by accounting-based such as return on assets (ROA) (Zahra Borghei et al., 2018; Matthias Damert et al., 2017), return on
equity (ROE) (Fortune Ganda & Khazamula, 2018; Matthias Damert et al., 2017), market-based such as stock return or
Tobin’s Q (Feng Shen et al., 2019; Yu He et al., 2017; Gilley et al., 2000; Li Chang et al., 2015); also there are some studies use
both of the accounting-based and market-based variables (Mikael Perdjean, 2019; Miroshnychenko et al. 2017).

The environmental performance also measured by vary variables can be categorised into three groups. First is a corporate
environmental performance which is the outcome of the firm activities that impact on the environment (Wall et al., 2011).
This group include some variables such as carbon emissions and waste (Carmen et al., 2018; Yasir Shabab et al., 2018). As a
minimum, in stakeholder theory corporate business has to improve their environmental performance to satisfy related
stakeholders, at least retain environmental legitimacy (Yan Qin et al., 2010). The second group is environmental disclosure, the
firm needs to disclose environmental information to interested parties to make decisions. They release the information
under voluntary and mandatory rules, both an annual report and sustainability reports (Frost, 2007), for example, lots of
firms in the world register in Carbon Disclosure Project (CDP) is a convenience for the cross country study of carbon
emission (Unerman & Chapman, 2014). The third one is environmental risk management, is corporate improve the
management structures and systems to adopt the sustainability development (Schulte & Trommer, 2012). Now firms with
more attitudes and objectives to enhance environmental risk management to avoid punishment by the environmental
protection agency. Such as carbon risk management can mitigate the penalty of firms (Peter Clarkson et al. 2016).

There are different resulted (positive, negative, no influence) had documented in previous articles. We focus on the
measurement of variables and the result of these papers. There is inconsistent result had founded between CEP and CFP
relationship, our sample from 90 empirical studies. We analysis the weather different variables measured in CEP and CFP
can determine empirical outcomes. The result shows that environmental performance generally positive related to
corporate financial performance. These studies also use different database to analysis, corporate financial performance use
RESSET Finance Research Database (e.g., Feng Shen et al., 2019; Zhifang Zhou et al., 2018), Compustat database (e.g.,
Carmen et al., 2018; Marilyn T Lucas, 2016) and annual report (Mengying Feng et al.,2018; Andewi Rokhmawati et
al.,2017). Corporate environmental performance often used CDP report (e.g., Matthias Damert et al., 2017; Yu He et al.,
2017), Kinder, Lyndenberg, Domini Research and Analytics (KLD) (e.g., Marilyn T Lucas, 2016; Ella Mae Matsumura et
al., 2014), Nilkei (e.g., Naka et al., 2007; Ting Ting Chen et al., 2014).
The result indicates how these various variables and different characteristics databases, data collection methods are influence the results. Besides, as well as the results also influenced by different theories and analysis methods. Some of the results suggest that financial benefits (both accounting-based and market-based) from environmental risk management and environmental performance are more than the environmental disclosure.

Keywords
corporate environmental performance (CEP), corporate financial performance (CFP), different variables measurement, vary data resources, causality.

Implication of a Cap-and-trade System for Sustainability under an Asymmetric Duopoly
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Abstract

There is now a near consensus that the current high levels of greenhouse gas emissions will likely change the earth’s climate in ways that people will regret. Actually, this climate change predominantly is caused by excessive carbon emission in the process of production (Georg, Rapke & Jørgensen, 1998). Therefore, carbon emissions reduction is not only a climate problem but a green supply chain issue in industries. The need for policies that seriously address emission reduction has become increasingly apparent. Carbon tax, emissions trading scheme (ETS) and cap-and-trade (CAT) system are regarded as the most efficient methods to reduce carbon emissions. Comparing with carbon tax, ETS is politically preferable in Mexican power sector but it is extremely complicated to set limits for allowance allocation (Camila et al., 2018). However, CAT system that offers the companies a cap to buy or sell carbon emission, adding them a great motivation to reduce carbon emission for decreasing cost or increasing earning, will effectively affect the development of sustainable supply chain (Yuan et al., 2018). IEA (2017) recommended governments to adopt CAT systems to cope with greenhouse climate and control (GCC), and CAT systems have drawn extensive attention in recent years (M. J. Yeo & Kim, 2012).

The conception of emission trade was first established by Dales (1968), and emission trade is now becoming the most important policy to cope with GCC. The CAT system stipulates the amount of emissions that must be reduced, and allows the market to determine the energy-related prices that are needed. The benefits of a CAT system include but are not limited to reducing emissions at a relatively lower cost, providing firms with flexibility to arrange emission schedules and motivating the development of technological innovation.

Since emission trade is a market mechanism that directly affects environmental quality, it has been widely adopted in many countries. By 2007, the first CAT system, as a part of the framework of the US Acid Rain Program in Title IV of the 1990 Clean Air Act, reduced SO2 emissions by 50% from 1980 levels and decreased the cost of controlling acid rain by 80% (Carlson, 2000). The European Union Emission Trading Scheme (EU-ETS) restricted carbon emissions by implementing a mandatory CAT system in 27 European Union countries in 2005 (Anouldis, 2017). By developing a cap for expected emissions, emissions were reduced by approximately 2.4% in 2010 (Jones, 2007). The European Environment Agency (2012) proclaimed that the emissions of 15 European Union countries averaged 11.8%, and these 15 countries surpassed their first Kyoto target by a wide margin.

ETs and CAT systems have been applied in many countries and investigated extensively (Hepburn et al., 2018; Sascha, 2016; Du et al., 2016). For example, the US and 27 countries in the European Union, have launched CAT policies in the last decade. In China, there is a largest CAT system of the world to regulate carbon emission in 2017 (Yang et al., 2018). ETs and CAT systems reduce emissions significantly (Schmalensee & Stavins, 2017), promote renewable energy development (Thompson et al., 2018; Shinkuma & Sugita, 2016), and improve environmental or clean innovation (Borghesi et al., 2015; Hall & Helmers, 2013).

Moreover, ETs and CAT systems are considered to be important mechanisms by many countries. Paltsev, Reilly, Jacoby, Gurgel, Metcalf, Sokolow & Holak (2008) assessed CAT in the US and forecasted the efficiency of ETs in the US. With a recursive dynamic computable general equilibrium (CGE), Lin and Jia (2017) studied ETs in China and found that CO2 emissions will reduce to 12.05 Brt-CO2 from 2017–2030 due to China’s ETS. The ETS in Germany was studied by Rogge & Hoffmann (2010), and they argued that the ETS promotes Germany’s sectoral innovation.

Many research articles concentrated on the effects of the CAT system on emission reduction and environmental innovation. Most of these scholars studied how the CAT system affects the production of companies and environmental protection. Sadok Turki (2018) studied the optimal carbon emission design for manufactured and remanufactured products. Wen Yang (2018) analyzed the effect of CAT system to reduce carbon emission for promoting the advance of green technology. However, few scholars have analyzed the performance of a CAT system under market power. In fact, there is market power in many industries. It is extremely important to capture the effects of a CAT system under market power. Hahn (1984) developed theory of market power in emissions markets by analyzing the emissions market in Los Angeles. An example of a CAT system under market power is the Regional Greenhouse Gas Initiative (RGGI) in the US. There is market power because the RGGI only covers the electricity sector, which is heavily concentrated (Noah 2017).
Furthermore, though numerous scholars have conducted many excellent studies on CAT systems and ETSs, few researchers have studied CAT systems linked with a social welfare. Actually, it is important for CAT system to consider social welfare into the construction.

Therefore, we use a game theory model and focus on asymmetric product efficiency affecting production and environment under market power. The effect of a CAT system will be divided to two conditions including fixed and variable emission trading prices to analyze. Besides, a social welfare function will be introduced to obtain the optimal emission cap in the stage of inconstant emission trading price. Then, there is some interesting findings consisting of cleaner production from the model.

This article makes three contributions. First, we capture the effects of asymmetric efficiency on production and carbon emission under market power, a real phenomenon in emission market, making the research more practical. Second, we introduce a social welfare function involving a parameter of negative externality of the industry and obtain the optimal total emission cap for social welfare maximization. Combining the market power and social welfare into our study fills a gap in literature. Finally, we find that the CAT system provides more incentives for less efficient firms than the most efficient ones. This finding identifies a market value of the CAT system for the development of technological innovation.

**Keywords**

Cap-and-trade system; emission reduction; emission cap.

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**Geothermal Resources Development Forecast Under Policy Incentives in China: A System Dynamics Analysis**

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**Abstract**

Energy is of extraordinary significance to the sustainable development of any country’s society, economy and environment. Energy is closely linked to industrial production, agricultural production, health care, water supply, population, education, quality of life and so on. Over the past decade, the energy consumption index has been on a worldwide upward trend (Yi, 2017). The overall economic growth of every country highly depends on its usage of renewable and nonrenewable energies. Energy is the lifeblood of modern industrial economies. For the last century, world economic growth has been largely affected by the supply of fossil fuel resources production and vice versa (Behdad, 2017). A sustainable supply of energy is key to future economic prosperity and environmental security.

However, with the rapid development of industrialization and economy, the world is being faced with imbalances and challenges of resource depletion and the deterioration of the ecological environment because of unreasonable development of mankind and the use of natural resources, as well as any emissions of pollutants (Abosedra, 2017 and Alam, 2012). Historical experience shows that energy, the environment, and the economy form an interrelated complex entity. The coordinated development of energy, economical, and environmental subsystems is not only an essential requirement of the sustainable development theory but also an effective way to achieve sustained, steady and high-speed development of the national economy. How to coordinate the relationship among the economy, energy, and the environment and how to explore their sustainable development have become important problems for the government and academia to solve urgently (Zuo, 2017).

Driven by climate change and fossil fuel depletion, renewable energy will undoubtedly become the developing trend worldwide especially in those countries which depend heavily on foreign fossil fuels (Liu, 2014). With the rapid development of China’s economy, fossil fuel-based energy consumption continues to increase. As a result, air pollution, greenhouse effects and other environmental problems have become increasingly prominent, seriously restricting the sustainable development of China’s economy (Fan and Lei, 2013). The State Council put forward their target for the reduction of emissions intensity from economic growth by 40–45% below 2005 levels by 2020 (The State Council, 2009). Faced with the pressing need to reduce coal-fired and environmental improvements the geothermal resource industry in China has achieved rapid development in recent years. Geothermal energy is a clean energy source that can potentially mitigate greenhouse gas emissions, as its use can lead to a lower mitigation cost (Jiang, 2019). The geothermal technologies should be advanced as a solution to global warming, air pollution, and energy security (Mark, 2009). However, research on the economic impacts of the geothermal industry is scarce (Jiang, 2019). The diffusion of geothermal resources development has been limited due to high costs (Lund, 2005). National incentive policy seems to be the only way to promote geothermal resources development. Thus the Chinese government has taken the development of geothermal resources as an important policy measure to reduce emission. Further, these policy measures are accompanied by policy incentives, including price subsidies, technology supporting and cost reduction. Nonetheless incentive policy will continue to bring new developing opportunities to China’s geothermal resources development. So it is of great significance to investigate China’s geothermal resources long-term developing pattern under policy driving.

System dynamics (SD) method can not only model system’s real behavior but also explain the relationship between main variables within the system (Sheikh Fini, 2014). It enables us to stimulate the cost decline, investment culmination and scale expansion, and optimize development patterns of China’s geothermal resources development in the new policy situation.
Analysis of the effect of textured cutting inserts with different cutting conditions for minimizing power consumption in turning of Inconel 718 steel using statistical techniques
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Abstract
Turning operation is one of the primary machining operations and enhanced machining performance is obtained by its process parameters. The economic and environmental benefits of turning operation are providing components with appropriate power consumption. In this work, the effects of textured cutting inserts and machining parameters on power consumption are evaluated in turning of Inconel 718 steel. Recently, textured cutting inserts are focused to obtain sustainable machining. Generally, textured tools are filled with solid lubricants to avoid hydrocarbon oil based cutting fluid. But, few researchers are reported about no systematic procedure of solid lubricants supply to the machining zone, problems in high temperature withstand or evaporation and chemical reaction between added and parent materials. Hence, in this work alternative coolant procedure is attempted for textured cutting inserts. Texture with ceramic coating, cryogenically treated and vegetable oil are the alternative coolant approaches are attempted. Statistical techniques such as signal-to-noise ratio, orthogonal array and Analysis of Variance (ANOVA) are utilized to find the effects and significant of machining parameters. The machining parameters selected are types of textures, cutting speed and feed rate in order to minimize machining power. Optimum process parameters are predicted using Taguchi method. Cryogenically treated textured inserts showed that less power consumption than other cutting conditions.

Turning is a primary and important machining process for metal cutting in engineering industries to obtain the desired shape and size. The achievement of high performance and selection of appropriate process parameters are significant tasks in turning operation. Machine tool needs power to give the relative motion to the cutting tool with respect to the work piece and rotation of spindle. The machining parameters influence the rate of material removal. The deformed chip thickness increases due to increase of feed rate and cutting speed which forces the machine tool to take more power. Also, sustainability performance is achieved by reducing the power consumption. This reduction of power consumption influences the environmental impact of power production.

Power consumption during machining process can be measured by following methods. Mathematically, power consumption can be determined by multiplication of cutting force and cutting velocity. In experiment, measurement of cutting force value may be accurate or inaccurate due to errors in instrument or may be from other sources of error. Researchers are suggested; to avoid this difficulty, power must be measured directly during machining. In Wattmeter measurement, multiplication factor is used to calculate the power consumption during machining. It is based on types of devices and also some basic knowledge is required to connect terminals to the machine with Wattmeter during measurement of power consumption. Power quality is the quality of current of voltage or current waveform. Any deviation of voltage or current waveform from standard value is known as power quality problem. The presence of harmonic creates torque pulsation which results errors in any measurement. Using power quality analyzer current harmonics and voltage harmonic can be measured. Hence, direct measurement of power during turning process, power quality analyzer is an accurate solution. It can also capable to measure active power, apparatus power, and power factor.

In this investigation Inconel 718 is selected as the work piece material which is highly temperature and corrosion resistance materials. The cutting tool material is used in this work uncoated tungsten carbide with grade of CNMA 120408. Figure 1 shows the image of cutting tool inserts. Textures are produced on the rake surface using wire electrical discharge machining process. Three types of texture are namely parallel type, perpendicular type and both parallel and perpendicular (i.e.) cross type. Generally, the machining power is estimated using the mathematical expression by considering main cutting force and spindle speed. Power quality analyzer (Eg: FLUKE 438, Ref Fig. 2) to measure the power consumption in Watts of cutting process is connected to the power supply of CNC turning center. Generally, the machining power is estimated using the mathematical expression by considering main cutting force and spindle speed. In some situations, the estimation of main cutting force may or may not be an optimal one. To avoid this difficulty, machining power is measured directly during machining.

From the result, minimum machining power is obtained in the combination of lower level of cutting speed and feed rate.
It is observed that, work material produces less resistance to cutting tool at lower level of cutting parameters. The difference of friction between the work piece material and cutting tool offers variation in the cutting forces which leads the power consumption. The increment of these factor influences rate of material removal hence the machine tool need to consume more power. When a higher level of feed rate is used, axis motors want to travel quicker and utilized more amount of power. The same one happens in the case of higher level of cutting speed, due to the spindle movement.

Solid lubrication produces, chemical reaction between added and parent materials and also chemical stability of the particulate addition in relation to the steel matrix and an investigation of changes in their composition and structure. Another problem is with solid lubricant supply to the machining zone. Ceramic coating on cutting inserts is a type of hard coating which generates high frictional coefficient and it further needs some soft solid lubricated coating. Vegetable oil is natural product and does not have any polluted element, but have problem in poor thermal stability and high viscosity. Cryogenic treatment on textured inserts is used to enhance the properties and reduction in power consumption is noticed.

Energy utilization in manufacturing sector is a significant contributor for analyzing global warming potential and environmental burden of manufacturing industries. Statistical tools are used to analyze the effects of machining parameters for machining power for the enhancement of sustainable performance through reducing power consumption. Machining power influenced by lower level of cutting parameters which offer low resistance between cutting tool and work piece material. Cutting condition plays a vital role in sustainable manufacturing. The electrical energy requirements of a machining process must to meet the machined work piece within the minimum power consumption and improve the sustainable manufacturing.

**Keywords**

Turning, textured inserts solid lubrication, ceramic coating, cryogenically treatment, and vegetable oil.

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**Experimental investigation on towards sustainable machining using cryogenically treated textured tools**

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**Abstract**

In manufacturing industry, machining process and its environmental effect analysis are very important for enhancement of sustainability analysis. In turning process, the heat is generated due to friction, and this heat can be removed by the application of cutting fluid. The cutting fluid serves as an agent to cool the cutting tool the cutting tool and lubricates between the tool-chip and tool-work piece interface, but it also produces environmental pollution and other operator health issues. To overcome this issue, some research works are focused with different types of textured surface on turning cutting tool inserts on rake surface for improvement of sustainability improvement. The application of solid lubricant on textured surface is observed to provide lubrication effect on rake face. But few issues are with solid lubricants. Hence, the present investigation is focused on the application of cryogenically treated textured cutting tool inserts on turning process and the result showed that solid lubricant applied to the textured tool can be eliminated.

Now a days, surface texturing is widely used for cutting tool inserts which is used to produce sustainable machining by applying the various grooves on rake surface. This surface texturing changes the surface topography of cutting tool inserts. Application of solid lubricant on textured tool produces a continuous solid lubricating layer on the surface of the tool due to the thermal expansion of heat produced during machining. This thin layer lead reduced friction, cutting force and temperature in the machining zone. These solid lubricant powders such as graphite, boron carbide, molybdenum disulfide, tungsten disulfide and calcium difluoride. Solid lubricants are lubricant materials which are basically solid but soft from frictional heat at the point of contact. Sometimes it produces, chemical reaction between added and parent materials and also chemical stability of the particulate addition in relation to the steel matrix and an investigation of changes in their composition and structure. Another problem is with solid lubricant supply to the machining zone. Most of the literature not mentioned about supply methodology. Supply of solid lubricant in the form of powders, paste and mixed with oil. Few literatures, specially made some device in the form of solid paste injection pump, supply with gravity force, supplied in the form of powder. In this work, to achieve eco friendly machining, and to avoid issues related to mineral oil based cutting fluid and solid lubricants, hence cryogenically treated textured and tempered tools are used. Cryogenic treatment is a type of heat treatment which is used to enhance the material properties such as wear resistance, reduced residual stress, refinement fine grain size, better electrical properties, toughness and making this process an eco-friendly process.

In this investigation, inconel 718 is used as the work piece material which is used for highly temperature and corrosion resistance requirements applications. The cutting tool material is used in this work uncoated tungsten carbide (make WEDIA) with grade of CNMA 120408. Figure 1 shows the image of cutting tool inserts. Textures are produced on the rake surface using wire electrical discharge machining process. Three types of texture are namely parallel type, perpendicular type and both parallel and perpendicular (i.e.) cross type. These textured cutting tool inserts are treated with cryogenic environment by -196°C and followed by tempering at 150°C. Figure 2 shows the cryogenic and tempering cycles on carbide inserts. The turning operations are conducted on CNC turning center with 7.5 kW spindle power. Taguchi L9 orthogonal
array is used to analyze the effect of process parameters on performance characteristics with minimum number of experiments. Input parameters considered are types of texture, cutting speed and feed rate. Output parameters considered are surface roughness, tool wear and tool vibration.

In this investigation, multiple outputs are considered and the experimental results obtained using L9 orthogonal array. Taguchi based Grey Relational Analysis (GRA) is used to investigate the experimental data. According to GRA, the highest value of grey coefficient is the level of optimum combination of control process parameters.

In surface textured cutting tool inserts, various types of pattern are available. The pattern of textured cutting tool insert is significantly affected in terms of machining performance. The lower value of surface roughness values are employed during turning process with perpendicular type textured pattern due to the chip flow direction rather than parallel type pattern. In parallel type pattern, adhesion between the tool and chip interfaces is observed. It is also observed that increased co-efficient of friction value is mention due to turn over of the chip. Hence, parallel type pattern have some negative effect compared to perpendicular pattern. The surface texture produced on cutting tool is used to reduce tool-chip contact length which is almost equal to a chip breaker. The formation of eta carbides, grain refinement, and transformation of retained austenite into martensite which occurs due to cryogenic treatment will increase the tool hardness. Along with increase of tool life cryogenic treatment also improves the tool resistance to chipping and flank wear resistance. Due to micro structural changes of the tool material, cryogenic treatment will have a beneficial or productive effect on the tool performance by avoiding premature wear and chipping. This also enhances the sustainability in manufacturing.

The main conclusions of this investigation are textured cutting inserts providing good machining performance, particularly perpendicular textured inserts. Solid lubrication has some disadvantages in the form supply, may have chemical reaction and high temperature withstand. Cryogenically treated textured inserts are eliminating solid lubrication, provides good machining performances and leads to sustainable manufacturing.

Keywords
Turning, Textured cutting inserts, cryogenically treated inserts, GRA.

Sustainable development evaluation of urban metabolism driven by innovation - A case study of Shenzhen
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Abstract
In the global scope, sustainable development has become a universally accepted goal of mankind, and the development model of circular economy has been widely concerned. The United Nations predicts that by 2045, the number of people living in urban areas will reach 6 billion. Cities contribute more than 80% of the world’s GDP and play an important role in global economic development. It is crucial to study the sustainable development level of urban system and promote the development of circular economy. As one of the central cities in Guangdong-Hong Kong-Macao Greater Bay Area, Shenzhen plays a leading role as a special economic zone, a national economic center and a national innovative city. In August 2019, the central government of China supported Shenzhen to build a pilot demonstration zone of socialism with Chinese characteristics.

Shenzhen has moved from "special economic zone" to "pilot demonstration zone". Innovation drive is the driving force of Shenzhen’s development, which has brought great opportunities to Shenzhen. The rapid development of Shenzhen city has brought many environmental problems to the ecological and economic system of Shenzhen city, such as greenhouse gas emission, increase of municipal solid waste, resource depletion and so on. In particular, urban metabolism consumes a large amount of natural resources, posing a threat to the sustainable development of Shenzhen. Therefore, in order to promote the sustainable development of Shenzhen and better play the exemplary role of Shenzhen as a national benchmark city, it is crucial to comprehensively evaluate the sustainability level of Shenzhen.

In the global sustainable development goals adopted by the UN general assembly in 2017, "building sustainable cities and human settlements that are inclusive, safe and resilient to disasters" has become an important part of the UN sustainable development agenda. From the research point of view, ecosystem services and natural capital support system has been gradually recognized the importance of urban economy, the internal value analysis to ecological economic system different types of energy and matter into a unified standard to value for analysis, building urban ecological benefits of intangible and tangible link between social and economic wealth. Therefore, in order to analyze the dynamic changes of Shenzhen’s urban eco-economic system driven by innovation, this paper comprehensively evaluates the sustainable development level of Shenzhen’s urban metabolic system driven by innovation based on the urban metabolism, energy analysis method and energy value index. The results show that from 2000 to 2017, the renewable resources of Shenzhen are very limited, and the import and export resources grow rapidly, with the total energy utilization increasing from 2.86E+236E to 6.57E+236E, indicating that the rapid development of Shenzhen consumes a lot of resources and highly relies on external resources. The energy ratio of waste increased from 0.46 in 2000 to 0.82 in 2017, and the sustainable development index of Shenzhen in 2017 was 0.66, indicating that the recycling capacity of waste in Shenzhen’s urban metabolism is weak, and Shenzhen’s urban metabolic system is far from sustainable development. The energy investment ratio of Shenzhen increased from 0.37 in 2000 to 0.71 in 2017, indicating that with the innovation and transformation development of Shenzhen, the resources purchased by the urban metabolic system from the outside world gradually increased, reducing Shenzhen’s
dependence on the local ecosystem to some extent. From 2000 to 2017, Shenzhen’s environmental load ratio was less than 3, indicating that Shenzhen’s urban metabolism was under low load, and Shenzhen’s environmental load ratio was better than that of Xiamen, Beijing, Guangzhou and Shanghai, indicating that the sustainable development level of Shenzhen’s urban metabolic system was relatively good.

Based on these results, some policy suggestions are put forward to improve the sustainability of Shenzhen, including improving the efficiency of resource utilization, vigorously developing circular economy, increasing the use of renewable energy and clean energy, and promoting the ecological industry, so as to promote the sustainable development of Shenzhen in the future.

**Keywords**

Urban metabolism, Emergy, Sustainability, Innovation driven, Shenzhen.

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**Evaluation System of Packaging Efficiency of Cold Chain Logistics**

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**Abstract**

Continuous evaluation and promotion of packaging efficiency of fresh agricultural products in the process of cold chain logistics transportation plays a positive role in improving the utilization efficiency of packaging and the quality of fresh agricultural products, reducing energy waste and environmental pollution caused by excessive packaging, reducing expenses and improving economic benefits. Nowadays, on the basis of the increasing demand for logistics distribution time and freshness of fresh agricultural products, the direct or indirect environmental pollution and resource waste in the process of transportation, packaging and sales of fresh agricultural products have attracted wide attention all over the world. Packaging, as an effective way to prolong the shelf life of food, is widely used in the preservation, transportation and transportation of food. Sales. Therefore, it is very important to reduce the unnecessary waste and energy waste of packaging and increase the safety and traceability of food by evaluating the packaging efficiency in the process of cold chain transportation. Therefore, many scholars reduce energy waste and indirect packaging waste and energy abuse by optimizing cold chain transportation path, changing product packaging form, looking for ideal storage temperature and so on. However, as an important part of the whole circulation field, the economic and environmental problems of packaging have not been effectively understood.

In order to quantify the packaging efficiency of cold chain logistics, this paper studies the typical packaging form of fresh agricultural products under the mode of electronic commerce in China, and puts forward a packaging efficiency evaluation method and system to reduce the waste of fresh agricultural products and the abuse of energy. By tracking the actual cold chain transportation process and ideal scenario simulation, the influence results of packaging are compared horizontally and vertically, and the quantitative and qualitative evaluation of cold chain logistics packaging at this stage is realized by this method. Therefore, we define that the packaging efficiency of cold chain logistics consists of four parts: damage prevention efficiency, packaging economic efficiency, microenvironment maintenance efficiency and environmental efficiency, which together affect the overall packaging efficiency. Advance Step by step, damage prevention efficiency is the ability of packaging to ensure the product from external environment interference in its life cycle and the safety performance of the product in the product cycle. The economic efficiency of packaging is first manifested in the proportion of packaging in the economic value of the product, and secondly, the resource efficiency of the packaged product in the unit module in the process of cold chain transportation. The efficiency of microenvironment maintenance is to maintain the quality of microenvironment products in the packaging unit, reduce the rate of quality deterioration, prolong the shelf life and reduce the performance of food waste, and the environmental efficiency is the energy consumption, recycling and environmental impact performance of packaging in the process of production and use. Finally, according to four effects, the influence weight of rate on the overall packaging efficiency is different, and the corresponding weight assignment of each packaging efficiency is carried out to form a comprehensive cold chain logistics packaging efficiency evaluation system.

The experimental results show that through the multi-dimensional comprehensive evaluation of the packaging efficiency of cold chain logistics, the packaging of fresh agricultural products can be predicted more objectively and effectively, which is helpful to increase the value of products in actual production and life, optimize the packaging form and packaging mode, reduce energy waste and environmental pollution, and is of more practical significance to the realization of cleaner production. At the same time, it will also provide the corresponding reference for the deep optimization of the next stage of packaging.

**Keywords**


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**Bibliometry Of Scientific Production From 2008 To 2018 On The Management Of Invasive Vegetable Species In Insular Environments**

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Abstract

Island environments have unique biotic characteristics, as fragility, depletion of natural resources, geographical isolation and fragmentation are determining factors in biocenoisis. This time, there are ecological vulnerabilities that occur in archipelagos, which are mainly influenced by anthropic actions and climate change. This study investigates the worldwide production about invasive species in islands to help researchers understand the level of research related to the theme. This studied the scientific production of 10 years (2010 to 2019) on the Web of Science and Science Direct platforms. Seeking to understand and analyze the real environmental impacts, as well as the management for their eradication and the necessary decision making for sustainable management. Furthermore, raising the quantification of the works and their distribution (quantitative analysis) was necessary to complement this study. The consultation applied at ScienceDirect system was TITLE-ABSTRACT-KEYWORDS ("Management", "Invasive Species", "Island") and TITLE-ABSTRACT-KEYWORDS ("Environmental", "Invasive Species", "Island"), given the growing public concern, academic, social, environmental and economic topics. Subsequently, the following steps were: data processing, quantitative and textual / qualitative analysis. This made through software such as Mendeley, Excel and Iramuteq. The analysis of the content of the scientific studies focused on the environmental impacts that invasive species cause in island regions, as well as the management methods and which stakeholders should take place in the sustainable management of islands. Mendeley assisted in the removal of duplicates, significantly reducing the amount of work, as well as the standardization and handling of them. In addition, the exclusion of articles that are not part of the central thematic axis analyzed by the researcher further reduced the sample. Initially, 358 publications address issues related to invasive species. In this sample, only English-language research articles were considered, excluding books, review articles, abstracts, news, among others. Moreover, after removing duplicates and material outside the thematic axis, the final sample consisted of 67 articles. Analyzing the cumulative quantity of publications on this subject, there is a significant increase in research. Thus, 24 publications are identified in the period between 2010 and 2014. In the last 5 years (2015 to 2019), this number has increased to 67 publications, which represents a 107.6% increase of the scientific articles. The analysis based on the final sample (n = 30) for the Engineering I assessment area shows that 33.35% of the articles are Qualis B2; 20.00% are Qualis B1; 13.33% are Qualis A2; 10.00% are Qualis A1, and finally, 53.35% do not have Qualis. For Environmental Sciences, only 6.66% of the journals had no concept, which may characterize that this area of knowledge is preferred by researchers regarding the issue of publications on the theme of plant invasions in environments, island countries and other geographical areas. Isolated. Moreover, there is a higher representation of Qualis A1 (53.35%); Qualis A2 (26.66%), Qualis B1 (6.66%) and Qualis B4 (1.29%). In this perspective, "Environmental Sciences" has greater impact or relevance with respect to publications involving alien species, as it has more publications in magazines A1 and A2 compared to "Engineering I". The 197 authors of various nationalities wrote the 67 publications. This time, in the last 10 years (2010 to 2019), 30 countries have published scientific research involving the theme of biological invasions caused by non-native plants. Thus, there are 4 countries that represent more than 50% of publications in the analyzed period. Among these countries, the United States of America - USA (33.33%) have the largest number of authors, followed by Australia (14.92%) and Italy (8.87%). The most prominent terms in textual analysis for repetition were specie (370), island (208), pant (175), management (117), invasion (104), native (103), area (80), alien (64), study (57), soil (48), conservation (47).

distribution (47), impact (44), tree (44), region (40), ecosystem (39), eradication (39). The number of research on biological invasions increases significantly over the years. In contrast, many studies portray the importance of reliable diagnosis as the basis information in the process of developing effective actions to eradicate non-native species. In addition, developed countries have greater assistance to those surveyed on the topic addressed, while developing nations still lack support in scientific production.

Keywords

Environmental impact; Environmental degradation; Loss of biodiversity.

Evaluating Industrial Symbiosis Exchanges Using a Life Cycle Sustainability Assessment (LCSA) perspective – An Eight-Capital Approach

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Abstract

Industrial Symbiosis (IS) is a way of collaborating among traditionally separate industries, finding ways to use waste from one as a raw material for another. To enhance IS approaches, it is important that the involved firms are aware of potential benefits created and make informed decisions. Many of the previous assessments have largely focused on environmental implications, few on economics, but social implications have been rarely reported, especially using very limited set of indicators like job creation, development of social ties and trust among partners. Life Cycle Sustainability Assessment (LCSA) covering all three dimensions are clearly lacking. In this study, we propose an eight-capital based approach from life cycle perspective, that expands the assessment of IS networks by evaluating environmental, social and economic dimensions: Life Cycle Assessment (LCA) to measure environmental aspects and energy consumption, Social Life Cycle Assessment (SLCA) to evaluate social impacts and Life Cycle Costing (LCC) to calculate the economic performance. This method is implemented in an IS site ‘The Plant’ in Chicago among five alternative fuel usage scenarios for baking
breads at an on-site bakery. Results show that biogas is the best choice in this study; combined heat and power co-generated in an Anaerobic Digester (AD) is the second-best; fuel option of waste heat from the oven follows with a slight gap; biobricks follow next, and business as usual scenario of wood as a fuel was ranked the last. The SLCA framework for an IS site is developed with relevant stakeholders, subcategories and performance indicators.

**Keywords**

Industrial symbiosis; Life cycle sustainability assessment (LCSA); Life Cycle Assessment (LCA); Eight-capital Approach; Circular Economy.

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**Interoperability Framework for Building Information Modeling based on Sustainability**

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**Abstract**

Green buildings are a growing trend in the construction industry, and the influence of sustainability must be considered not only the design stage, but also the entire lifecycle of the AEC (Architecture Engineering and Construction) industry. BIM (Building Information Modeling) can allow the management of the life cycle improving interoperability and allowing for more efficient and sustainable buildings (Wong and Zhou, 2015). The lifecycle of a building is constituted of five stages: design, construction, operation, maintenance and demolition. Each stage presents different challenges for sustainable construction and influences it in different ways (Muller et al., 2019). For example, the impact of the use of concrete structures is not relevant during the operation stages, however, it impacts the demolition stage largely, since concrete residues have a great environmental impact (Mehta, 2011). To ensure interoperability, four concerns must be considered: Business, Service, Process and Data. Business considers interoperability in a strategic level, involving regulation and standards. Service describes the interoperability of third parties, while process is concerned with the sequencing of activities. Finally, data structures interoperability in software and systems, so information can be exchanged smoothly (Chen, 2008). This way, information can permeate the lifecycle without losses, supported by process coordination and providing sustainability data sharing among the actors involved in creating more sustainable buildings. Important tools for improvements in sustainability in the construction industry are green certifications, such as LEED (Leadership in Energy and Environmental Design), developed in 1998 by the U.S. Green Building Council (USGBC) to provide the construction industry a framework for identifying and implementing green buildings. Other certifications such as Building Research Establishment Environmental Assessment Method (BREEAM – UK) and Green Star (Australia) are also relevant (Oti et al., 2015), but not to the same extent as LEED (Costa et al., 2008, Ma and Cheng, 2017).

This study will present a framework for BIM sustainability in an interoperable environment. Interoperability will work as a structuring element to provide a model for green BIM, based on three layers: data, service and process, and business. An ontology can be used to structure data and knowledge in any field, so, on data layer an example of an ontology for concrete structures is created using standards and manuals (Gao et al., 2017). This ontology was also partly based on IFC structure (industry foundation Classes), which is a format for BIM interoperability. This ontology acts as knowledge repository and it also can aid the development of IFC standards, by expanding its semantic base. In the process and services layer, a process model is structured using BPMN (Business Process Model and Notation) to organize the information flow. The process is obtained by either by structured interviews and through Delphi method, for all the lifecycle stages.

The data, services and process layers are connected through semantic annotation (Liao et al., 2016), in such way each task of the process is marked with the parts of the ontology used on that specific activity, making it easier to determine the flow of information. This relationship is obtained through structured interviews with professionals from the AEC industry, from each stage of the lifecycle.

Finally, the business layer is structured using a sustainability standard, guideline or certification manual. LEED guidelines manual was loaded into a QDA software (Qualitative Data Analysis) and crossed with the ontology described earlier, and a term recurrence analysis was performed. This way, a matrix was obtained presenting which concrete ontological concepts influence which LEED fields. It was noticed, for instance, that concrete resistance has influence on indoor environmental quality, as expected, since concrete quality relates to insulation.

Since the ontology connects both the process and the sustainability guidelines, one can observe which process’s decision points are influenced by the standards and certifications and use this framework to make more sustainable decisions. Finally, this model is structured in an As-Is and To-Be stages, where a basic structure considering current technology in use is created and a reference model is developed providing the guidelines for further improvement in sustainable interoperability. This framework can be applied for different fields in sustainable engineering, aiding the improvement in the lifecycle of environmental efficient buildings.

**Keywords**

Green Buildings, LEED, Ontology, Process, lifecycle.
Opportunities to going green by recycling the construction waste: A case of pioneer in Beijing
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Abstract
The process of urban and rural integration is accelerating in China, which produces 6 billion tons of garbage every year, due to large-scale demolition and construction, including 2.4 billion tons of construction waste, accounting for 30-40% of the total urban waste. However, as far as the current situation is concerned, the recycling rate of construction waste in China is still less than 5% while that in developed countries is more than 90%, or even up to 97%. To improve the efficiency of resource disposal and utilization ratio, in April 2018, the Beijing Municipal Commission of Housing and Urban-Rural Development along with other 12 departments jointly issued a new departure, "The Work Opinions on Further Strengthening Comprehensive Utilization and Recycling of Construction Waste" to further strengthen the comprehensive utilization of construction wastes in Beijing.

We hereby select the pioneering construction waste treatment plant which locates in the Daxing District in Beijing for our case study. A cost and benefit analysis along with the carbon emissions accounting has been carried out to investigate whether the demonstrated construction waste treatment plant is an economically feasible choice for abating the carbon emissions and climate change. Our study indicates that while disposing the construction waste in Daxing Plant, each ton of comprehensive utilization of the waste would reduce 0.21 ton CO2 and bring 20.268 CNY profits, letting alone some potential co-benefits such as reduction in the land occupation for piling up and landfills for the construction waste and local employment into account.

Keywords
construction waste, recycling, cost and benefit analysis, carbon emissions accounting, economically feasible choice, climate change mitigation, Beijing, China.

Heavy Metals Chloride Removal from Phosphorus-enriched Sludge Ash in Calcining Process under the Influence of Calcium and Potassium
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Abstract
With the high-speed development of economy and continuous improvement of people's living standards, a great number of sewage sludges produced annually in China. As a by-product, the sewage sludges generally contain high elements needed for the growth of plants. For example, sludge was having considered as the largest secondary phosphorus resource, recovering phosphorus resources from sludge has been becoming a research hotspot. However, heavy metals control is critical when using thermochemically recovering phosphorus (P) from sewage sludge ash (SSA). The studies described in this paper focused on the influence of different additives (Ca, K, Cl) for the removal characteristics of heavy metals in phosphorus-enriched sewage sludge ash (PSSA) through calcination.

Ca, as an alkaline-earth metal, increased the melting temperatures of PSSA and promoted the removal of heavy metals in PSSA. The DT, ST, HT and FT of PSSA were increased from 1256°C, 1309°C, 1327°C, 1346°C to 1279°C, 1328°C, 1361°C, 1380°C, respectively, when the addition of Ca was 4%. Compared to the case without Ca-addition, the particle surface of PSSA after calcination formed a significant amount of cylindrical rod-like and porous structures when the addition of Ca was 4%. Meanwhile, the chlorination reaction between the Cl-donor and the heavy metals were occurred more easily with the increased superficial area, thereby increasing the removal efficiency of heavy metals. With the addition of Ca was 1%, 2% and 4%, the removal of Cu was increased by 2.17%, 7.84%, and 11.67%, respectively.

However, K decreased the melting temperatures of PSSA and had a detrimental effect on heavy metals removal. The DT, ST, HT and FT of PSSA were decreased from 1256°C, 1309°C, 1327°C, and 1346°C to 1283°C, 1240°C, 1256°C, respectively, when the addition of K was 4%. Comparing to the case without K-addition, the particle surface of PSSA after calcination exhibited a substantially smooth structure when the addition of K was 4%. The chlorination reaction between the Cl-donor and the heavy metals became more difficult with decreased surface area, and the removal efficiency of heavy metals was also decreased with the nonporous particle surface.

The PSSA samples were mixed with different percentages of Cl to investigate its influence on heavy metals speciation. Similar research on metal speciation has been already described in a previous publication, but experiment samples of BCR in this paper were prepared by rotary kiln instead of the tube furnace. Usually, the speciation of heavy metals in BCR is divided into four forms: acid-soluble form (ACE), reducible form (RED), oxidizable form (OXI) and residual form (RES).
Nevertheless, the ACE and RES were the major research objectives in our project: more RES and less ACE were aimed at PSSA. Thus, the RED and OXI were added together in this paper to make RES and ACE more obvious. CI had a significant influence on heavy metals speciation in PSSA. Cu, Zn, Ni, Cd, Pb, and Cr in PSSA were mainly present as the RES after calcination without CI addition, and the content of RES reached over 80%. However, compared to the sample after calcination without CI addition, the RES of Cu, Cd, Ni and Pb were decreased 13.58%, 15.69%, 13.07%, and 28.76%, respectively, when the addition of CI was 5%. Therefore, the RES content of Cu, Cd, Ni and Pb in PSSA decreased with increasing the amount of CI-donor after calcination. With the increasing addition of CI, the RES of Zn, Cd, Ni, and Cu decreased constantly, while the RES of Pb, As and Cr were stable and nearly did not change with the different addition of CI.

**Keywords**
Sewage sludge ash, Heavy metals, Chloride removal, Speciation distribution.

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**Effects of particle size and additives on the formation of fine particulate matter during process of sludge incineration**

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**Abstract**

Municipal sludge, as an inevitable by-product during the wastewater treatment process, was there was a rapidly growing rate of sludge production worldwide. On account of the complicated and various compositions of the sludge, the formation of fine particles was inevitable and it did cause serious potential harm to the surrounding environment and creatures during the incineration process. Besides, as components of particulate matter, heavy metals were volatilization easily and condensation, which restricted the utilization of sludge. In this paper, the effects of temperature, particle size, and calcium-based additives on the formation characteristics of fine particulate matter were studied during the process of sludge incineration in a lab-scale fluidized bed.

The results revealed that the fine particulate matter had a bimodal distribution and the two peaks located around 0.5μm and 4μm, respectively. With the increase of temperature from 750°C to 950°C, the mass concentration of PM0.5 increased 12.88 mg/m³, while PM5 increased 57.7 mg/m³, which indicated temperature has a greater influence on coarse mode particulate matter. With the incineration temperature increases, the fine particles were converted into irregular spherical small particles from some relatively regular spherical large particles, the consists of particles were getting complicated and scattered, which included more heavy metals particles and mineral particles. The main reason for this phenomenon was that with the incineration temperature increases, the release concentration of heavy metal vapor in the sludge increases the number of nucleation particles per unit volume. During the condensation process, the particle boundary vapor saturation of the particle changes, resulting in the difference in microscopic morphology after the formation of fine particles.

The yield of fine particles was a closed link to the feed size of sludge. The number of fine particles increased since smaller the sludge feed size. As the sludge feed size increases from 150μm-187.5μm to 250μm-500μm, the particle size distribution of mass concentration of fine-mode particulate matter decreased significantly from 2.49 mg/m³ to 1.58 mg/m³ at the peak. Similarly, the particle size distribution of mass concentration of the coarse-mode particles decreased from 17.16 mg/m³ to 3.17 mg/m³. The fine particles were aggregated into irregular large particles by some relatively scattered regular spherical small particles. The density between particles was getting loose and uneven.

Furthermore, the results indicated that CaO can inhibit the generation of fine particles. When the additive ratio was 3%, 6%, 9%, the mass concentration of PM0.3 decreased to 53.7%, 63.5% and 86.1%, while the mass concentration of PM3 decreased to 43.9%, 74.7% and 91.7% when the ratio was 0%, the fine particles produced are simply composed of a plurality of regular spherical small particles, and when the additive CaO was added in an amount of 3%, Larger particles whose diameter are 756.6nm have already appeared. When the additive CaO was added in an amount of 6%, it can be seen in the SEM image that the particles were not simply stacked, while aggregated to form a bulk as a whole, and the partial particle diameter reached 800-900nm. When the additive CaO was added in an amount of 9%, the fine particles aggregate and become a larger spherical whole. The addition of calcium oxide promoted the growth, fusion and connection between some particles, and the more calcium oxide was added, the larger the diameter of the particles, and the more obvious the particle growth.

**Keywords**
Sludge incineration, fine particles, occurrence mode.

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**Energy-water-land nexus in transnational trade: The Belt and Road**

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Abstract
Economic globalization and population growth have greatly challenged energy, water and land resources to meet demand at national and supra-national level. The Belt and Road, a major global initiative of China, plans to build-up a new future oriented consensus for international cooperation with trade as one of its core fields. The initiative has severe implications for economies, policies and societies and reflects a new phase of globalization yet the accompanying natural resource exchanges has received little attention. The greater interdependence across regions increases production and trade of goods and services, and these activities require the input of water-energy-land and generate disturbances in the environment. The multi-regional input-output approach is utilized in energy-water-land nexus analysis of the Belt and Road, and to assess competing demands for these resources and environmental outcomes.

This analysis demonstrates the hidden virtual flows of water, energy, and land embodied in transnational trade. China has a close energy, water and land resource trade relations with Russia, India, Indonesia and South Korea but comparatively weaker trading relationships with the central and eastern European countries along the route, and instead they rely on countries other than China. The propose nexus strength indicator ranked countries based on its combined resource use in economic process (i.e. production and consumption related activities) and evaluate pressures on energy, water and land in a specific economy caused by international trade. With respect to production based and consumption based, no significant changes were noted and largely shows the same nexus strength values and resource configurations. It is somewhat consistent with domestic output levels as giant developing economies such as China, India and Russia showing large nexus strength values. The analysis lay the groundwork for assessing interrelation and interaction among three environmental elements using the MRIO model. Thus, conventional energy, water and land policy in “silos” should give way to nexus thinking.

As such the study is intended to serve as a reference work for policymakers and researchers primarily those working in Belt and Road countries that can build on to conduct more detailed assessments in future.

Keywords
urban transportation infrastructure, life-cycle analysis, energy and carbon footprint, Guangzhou City.

Ecotoxicity of polystyrene microplastics and glyphosate on the free-floating macrophytes
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Abstract
The rapid development of economy and society worldwide has resulted in serious environmental problems due to pesticides and microplastics in bodies of freshwater, which has led to the deterioration of these aquatic environments (Dhote and Dixit, 2009; Eerkes-Medrano et al., 2013; Li et al., 2018). Glyphosate (N-Phosphonomethyl glycine) pollution is one of the most influential types of pesticides. It is a highly efficient weed control properties and low-toxicity organic broad-spectrum herbicide in the environment (Mann and Bidwell, 1999; Liu et al., 2019). Although glyphosate herbicides are not allowed for use in the aquatic environment; however, measurable quantities of the active ingredient and surfactants are detected in surface waters, due to surface runoff and unreasonable use (Annett et al., 2014). Thus, glyphosate may potential to alter the physiology of aquatic organisms (microorganisms, invertebrates; amphibians and fish etc.) (Bonnet et al., 2007; Perez et al., 2007; Moore et al., 2012; Hued et al., 2012). Previous studies have shown that glyphosate causes adverse effects on photosynthesis, nutrient accumulation, nucleic acid biosynthesis, symbiotic N2 fixation, water absorption and biomass production within plants (Zobiole et al., 2012; Geiger et al., 1999; Ribeiro et al., 2008). For example, glyphosate can induce oxidative stress in Lemma minor through H2O2 excessive accumulation by targeting the mitochondrial electron transport chain (Gomes and Juneau, 2016).

Plastic pollution is a substantial environmental problem, because its low production cost and massive uses has led to the ubiquitous occurrence of microplastic particles in the natural environment (Dawson et al., 2018; Hartmann et al., 2019). In recent years, microplastics have also been found in freshwater ecosystems (Lechner et al., 2014). Microplastics can decreased the viability of root cells of duckweed Lemma minor (Kalicki et al., 2017). High concentration microplastics can reduced the shoot length of Myriophyllum spicatum (van Weert et al., 2019). However, few studies investigate the environmental chemical processes of this combined pollution in bodies of water and their phytotoxicity to higher aquatic plants.

As primary producers, aquatic plants supply food to the first consumers, and provide habitats and refuges for aquatic organisms (Borner and Putjalon, 2011). These plants are used as indicator organisms for ecological risk assessment, due to their wide distribution in the aquatic ecosystem (Kalicki et al., 2017). This, our study focused on investigation of the ecotoxicity effects of polystyrene microplastics and glyphosate on the free-floating macrophytes that might help in understanding of the effects of microplastics and glyphosate on the water-plant ecological system. In this study, higher aquatic plant Salvinia cucullata were exposed to polystyrene fluorescent microplastics (PS-MPs) (9μm with 0, 3, 15 and 75 mg/L), or glyphosate (0.5, 25, 50 mg/L), or polystyrene fluorescent microplastics + glyphosate mixtures (0, 3+5, 15+25 and 75+50 mg/L) for 7 days.
The results showed that the relative growth rate (RGR), catalase (CAT) enzymes activity, soluble protein, root activity and photosynthetic capacity of S. cucullata decreased under different concentrations of glyphosate, whereas superoxide dismutase (SOD) enzymes activity, malondialdehyde (MDA), and yellow leaf percentage significantly increased. After seven days of incubation none of the PS-MPs treatments affected the specific leaf growth rate and photosynthetic of S. cucullata. However, PS-MPs significantly decreased RGR, CAT, root activity of S. cucullata, whereas SOD and ascorbateperoxidase (Apx) enzymes activity significantly increased. Mixtures treatments significant increased enzymes activity (SOD; CAT, Apx) and yellow leaf percentage, whereas root activity, leaf growth rate and photosynthetic significantly decreased. Synergistic effects were elicited at higher doses (215±35 mg/L).

Thus, polystyrene microplastics can undergo complexation with glyphosate. As the concentration of pollutants increases, their complexation will saturate. Toxic concentrations of polystyrene microplastics and glyphosate caused oxidative damage as evidenced by activated the antioxidant defense systems, including increased lipid peroxidation and decreased chlorophyll and protein contents. Oxidative stress over a certain range will cause peroxidation product accumulation, impaired leaf and root growth performance. These findings indicate that the ecotoxicity of glyphosate or polystyrene microplastics may be aggravated in freshwater environments and caused obvious damage to floating plants.

**Keywords**
Microplastics; Ecotoxicity; Antioxidant defense systems; Glyphosate; Aquatic plants.

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**Measuring Metabolic Efficiency of Beijing-Tianjin-Hebei Urban Agglomeration:**

**A Slacks-Based Measures Method**

**Abstract**

This paper evaluates the metabolic efficiency of Beijing-Tianjin-Hebei urban agglomeration with an aim to promote the synergistic governance. The evaluation is targeted at the period from 2005 to 2017 and adopts the Slacks-Based Measure (SBM) model from the perspective of energy metabolism. The comprehensive metabolic efficiency is decomposed into economic efficiency and environmental efficiency. Using Malmquist index to dynamically analyze the trends and influencing factors of metabolic efficiency. It also analyzes the reasons for the ineffectiveness of the metabolic efficiency and the potential for improvement from the perspectives of output redundancy and output insufficiency. The results show that: (1) The energy consumption structure of terminal sectors is gradually improving, but the total amount of pollutants continues to increase. (2) The comprehensive metabolic efficiency is relatively low, but it has been rising gradually after 2012, the economic efficiency is higher than the environmental efficiency. (3) Tianjin has the highest comprehensive and economic efficiency, and Beijing has the highest environmental efficiency. Hebei rank at the bottom in terms of all. (4) The Malmquist index is on the rise and mainly influenced by technological progress. The efficiency could be improved by enhancing economic output, coordinating pollution governance, and moderately increasing the population size.

**Keywords**
Urban Metabolic Efficiency; Energy Metabolism; SBM; Synergistic Governance.

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**Energy conservation and emission reduction mechanism analysis of the industrial symbiosis system based on complex system simulation and MaOP algorithm**

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**Abstract**

Under the current situation of narrowing potentialities and rising marginal costs of single-industry energy conservation and emission reduction, as well as increasing environmental management goals, it has become the new future policy breakthrough to conduct collaborative management of energy conservation and multi-pollutants emission reduction through industrial symbiosis. Currently, limited by the micro research scale (i.e. enterprises or industrial parks) and the black-box analysis method (i.e. statistical analysis, etc.), most research on industrial symbiosis cannot trace the energy conservation and emission reduction performance of each symbiotic technology path, let alone analyze and solve the problem of collaborative management of multi-environmental goals within the symbiosis system.

This research aims to explore the mechanism of energy conservation and emission reduction of the industrial symbiosis system by developing an Industrial Collaborative Energy Conservation and Emission Reduction Model (ICECER). This model integrates complex reformation technological system simulation, energy conservation and emission reduction potential and investment cost evaluation, many-objective optimization of the technology path in the symbiosis system with a modified NSGA-III, and industrial symbiosis management application under uncertainties. By applying this model to an industrial symbiosis system with the “iron and steel - thermal power - cement” industries as the core, the results showed that:

(i) Industrial symbiosis could effectively expand the energy conservation and emission reduction potential in industrial
sctors. Compared with 2014, by adopting the above industrial symbiosis system, the realizable amounts of energy conservation and SO2, NOx, PM emission reduction in 2020 were predicted to account for 9%-43% of the total energy conservation and emission reduction goals of the 13th Five-Year Plan of the above three industries. (3) The complex synergetic or conflicting relationships among environmental management goals and economic goals were validated. There existed strong synergy among energy conservation, SO2 emission reduction and NOx emission reduction objectives while the PM emission reduction objective showed a loose relationship with the other environmental objectives. The marginal cost functions all presented exponential relationships and the increased PM emission reduction led to the fastest growing economic cost. (5) Considering the uncertainties in the future, from 2020 to 2030, we could target a long-term goal of this symbiosis system at energy conservation of 3.274, thousand tons of coal equivalent, emission reduction of 9.8 thousand tons of SO2, 15 thousand tons of NOX and 43 thousand tons of PM, with an investment of 3.8854 million RMB. (4) High priority should be given to the following three aspects in the long term: speeding up the utilization technologies for waste heat and waste pressure, and the collaborative disposal and reutilization of urban wastes in industrial sectors; increasing the investment on R&D and demonstrative project construction of three types of symbiosis technologies which involve industrial solid waste - environmental protection materials, industrial by-product gas - high value added chemical products, and industrial solid waste - new building materials; and accelerating the symbiosis utilization way of the blast furnace slag, fly ash, flue gas desulfurization gypsum and bottom ash to transform to a more environmentally and economically efficient way.

**Keywords**
energy conservation and emission reduction, industrial symbiosis, bottom-up modelling, many-objective optimization, uncertainty.

**Assessing the impacts of hydropower operation policies on stored and discharged water quality**

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**Abstract**

Dam construction for hydropower generation dramatically alters natural river flow regimes, simultaneously altering the retention and transport of nutrients as well as water quality in river systems. Hydropower operation policies determine reservoir storage and release decisions, which affect stored and discharged water quality through complex influences on hydrodynamic, temperature, light, nutrient and sediment conditions. However, the impacts of hydropower operation policies on water quality and the influencing mechanisms are unclear and require further investigations. In this study, we apply a comprehensive modeling approach to assess the influences of hydropower operation policies on stored and discharged water quality, and analyze the key factors and processes driving these influences. We assess the water quality impacts of three common hydropower operation policies with different management targets, namely, maximizing total hydropower generation, enhancing hydropower supply reliability, and eco-friendly operation that accounts for both ecosystem and human demands. A reservoir operation simulation model is developed to generate release schedules for all three operation policy scenarios. To simulate water quality under each policy scenario, we apply an integrated water-sediment simulation model that is capable of simulating hydrodynamic conditions, nutrients (nitrogen, phosphorus and carbon) cycling, algal dynamics (cyanobacteria, green algae and diatom algae) and matter exchanges between water and sediments. The model is developed at the Environmental Fluid Dynamics Code platform, which is a state-of-the-art 3D surface water modeling system supported by U.S. Environmental Protection Agency. It accounts for growth, basal metabolism, predation, settling, and external loads in algal dynamics simulation. Algal growth is affected by nutrient availability, ambient light and temperature. After simulating water quality for all operation policy scenarios, the impacts of hydropower operations on stored and discharged water quality are investigated, and the driving factors and processes are analyzed. Based on water quality analysis results, we propose management strategies and suggestions for dam operation to sustain both hydropower supply and healthy river ecosystem.

**Keywords**

sustainable hydropower, water quality simulation, reservoir operation, environmental effects ecological restoration.

**Emery-based assessment of ecosystem services and dis-services of the wetland in cities**

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**Abstract**

Urban areas only cover about 2.4% of the land area thus having a very high population density. Ecosystems in urban areas play an increasingly key role in the well-being of the inhabitants of these highly modified landscapes. Their ecological value has often been considered limited due to their size and degree of artificiality. The complexities and differences of urban wetland ecosystem, the uncertainties of ecosystem services (ES) delivery mechanism, as well as the unified accounting method still bring challenges for assessing urban ecosystem services valuation (ESV). Urban constructed wetland hydrology
is highly dynamic with wetlands exposed to extremes of drought or complete inundation for months. Depending on the regional hydrogeology and geomorphology, constructed wetlands can play important roles in storing rainwaters, controlling groundwater levels and altering surface discharge. Accounting for the daily changes in the solar energy of these flows and stock changes can be accomplished by employing temporally dynamic energy accounting. Energy is a donor-type value, which is determined by the production process and not by human’s preferences or willingness to pay. Under these circumstances, small scale urban ES have been classified into direct services (biomass increase, water supply, etc.), indirect services (air, water and soil purification, etc.) and existing services (climate regulation, recreation and education value etc.). In addition, urban wetland provides a wide variety of ES, which confer critical benefits to urban and peri-urban residents, but several ES have been reduced due to loss of blue infrastructure in the cities. Review indicate that integrating a WSMS into the watershed increased landscape productivity, decreased surface discharge and increased surface water storage. The eco- hydrological value of watershed productivity was 367 EM$/ha-1-yr-1$ when 10% of the watershed was wetland, which was an increase of 65 EM$/ha-1-yr-1$. Average emdollar value of water saved per unit of wetland was 143 EM$/ha-1-yr-1$. Besides these services, urban wetland ecosystems also produce dissipates, such as production of methane, deterioration of infrastructure, mosquitoes; biological hazards such as diseases, allergic and poisonous organisms. Dis-services are the important feature of a small-scale ecosystem in cities, which can’t be ignored. Therefore, there is a need to inform policy makers and urban managers about potential application of ESV for better urban ecological management.

**Keywords**
wetland, ecosystem services, energy-based method, dis-services.

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**Global energy interconnection’s social-economic implications – a case of the backbone network**

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**Abstract**

Global energy interconnection (GEI) draws a new outlook for world energy and economic development. The GEI backbone network (GBN) is GEI’s key project that sets up the main intercontinental power transmission networks. This study uses general equilibrium modelling to quantitatively analyze the social and economic implications of GBN. Major modelling efforts include: 1) incorporating the GTAP-power database into the GTAP-E model, 2) constructing a new fuel-factor nesting structure, 3) estimating the constant elasticity of substitution (CES) parameters between the fossil fuel power generation and a non-fossil fuel power generation bundle, 4) fitting the model with MONASH-style dynamisms, 5) setting up a base-case (for years between 2015-2050) consistent with the New Policy Scenario outlined in the World Energy Outlook 2015, and 6) designing and modelling the operation of the backbone network (for years between 2030 and 2050).

Modelling results suggest that, by 2050, compared to the base-case, the backbone network will increase world GDP by 0.35 per cent; all regions represented in our analysis will benefit from GEI development; world outputs in coal, oil and gas will fall by 1.4, 0.2 and 0.9 per cent, respectively; the share of renewable energy in total electricity and total primary energy will increase by 4.3 and 2.9 percentage points, respectively; and global CO2 emissions will fall by 0.72 per cent. Macroeconomic as well as sectoral results will also be shown and discussed at the regional level.

**Keywords**

GEI, CEG, GTAP, CES, GDP, CO2.

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**Accelerating the Scale-up Towards the Circular Economy Pattern: From an Eco-industrial Park towards an Urban Agglomeration**

**Beijing Normal University, 100875, China**

**Abstract**

The circular economy gains much more priority and concentration from the last few years not just only in EU and China but in the whole world because of the exploitation of natural resources as consumption and production. The reason behind is rapid increase in the world’s population. The key purpose of implementing CE is to reduce the industrial and city wastes, efficient use of resources, and innovation in technology, sustainability and have a balance in three important sectors, environment, economy and society. In this paper we deeply studies and review the CE pattern from an Eco Industrial Parks (EIPs) to Urban agglomeration, the history of CE, the barriers to CE, the evolution of CE in China and EU, from the perspective of environment, economy and society and a comprehensive review for the laws and policies, standards and some evaluation methods. The CE approach regarding the laws and policies is actually the top-down approach on national political level while other developed countries like Japan, EU and USA, it is a bottom-up method which is used for policies with respect to environment and waste management. The CE idea is still on its early stage especially in EU as compared to China because it’s a new concept and requires a lot of efforts, innovation in technology and methods. In early time the focus were on production but now the trend changes from production to consumption so here we also raises one question which is related to consumers that Role of consumer as part of the supply chain and innovative agent in the
development of CE. The new methods which is recently introduced for implementation of CE are "Eco Innovation (EI) key element to carry out the transition from linear to circular system of consumption and production process and CE oriented Business Model Innovation (BMI). However still there is need for advancement and efficiency in both the streamline.

**Keywords**
Circular economy, Eco industrial parks, urban agglomeration

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**Energy conservation and emission reduction mechanism analysis of the industrial symbiosis system based on complex system simulation and MaOP algorithm**

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**Abstract**

To investigate the impact of the increase in runoff variability on hydroelectric generation under climate change and quantify the effect of the improved regulation strategy on the mitigation of runoff variability increase, this study took the cascade power stations in the lower reaches of the Lancang River as an example. Firstly, the trend of precipitation in the regional climate model was removed and the de-trending precipitation was the input of hydrological model for simulating runoff; secondly, reservoir regulation strategy of historical and future scenarios was simulated with the optimal regulation graph which was made by the Genetic Algorithm; the optimal regulation graph based on historical runoff was applied to the future scenario, exploring the impact of the increase of runoff variability; finally, the regulation graph was re-optimized according to the runoff of the future scenario, quantifying the impact of adjusting regulation strategy on the mitigation of the effect of climate change. The results show that: 1) the increase of runoff variability can reduce the total amount of power generation and significantly reduce the guaranteed rate without changing the total amount of incoming water; 2) the improvement of the regulation strategy can improve the total amount of power generation and the guaranteed rate, however, it is still difficult to restore to the level of the historical period; 3) there is a competitive relationship between the guaranteed rate of power generation and the total power deficit.

**Keywords**
energy conservation and emission reduction, industrial symbiosis, bottom-up modelling, many-objective optimization, uncertainty.

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**A hybrid super slack-based measure and uncertainty analysis method for evaluating and forecasting the energy-environment efficiency in the temporal and spatial perspectives**

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**Abstract**

Energy is vital to economic progress; however, global-climate and environmental damages have been caused by the increased need for fossil fuel resources especially with the rapid increase in urbanization. To analyze the environment and resources sustainability in the background of rapid economic and social development, a hybrid method was proposed in this study, incorporating super slacks-based measure (SBM) and uncertainty analysis. The methodology can (a) measure energy-environment efficiency in consideration of indicators of desirable output (i.e., GDP) and undesirable outputs (i.e., CO₂ and SO₂); (b) assess resources and environment sustainability in the process of future urbanization based on multiple scenarios; and (c) assess the features of regional energy efficiency in the temporal and spatial perspectives. To illustrate the application of the method, a case study was proposed in the Guangdong-Hong Kong-Macao Greater Bay Area Strategic solutions for resource management could be obtained focusing on environmental and social development of the study area. Thus, the study could support decision-making in energy conservation, emission mitigation and economic development of urban cluster.

**Keywords**
Energy-environment efficiency; Uncertainty analysis; Slacks-based measure(SBM); Guangdong-Hong Kong-Macao Greater Bay Area.

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**Assessing the impacts of hydropower operation policies on stored and discharged water quality**

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Abstract
As one of the most important parts of urban infrastructure, transportation infrastructure has aroused great attention in its potential for energy use reduction and carbon emission mitigation. Guangzhou has built up an extremely powerful comprehensive transport network in the past few decades, and this network will be even bigger by 2035 according to the city planning, which poses a major challenge of alleviating energy and carbon footprint under the future traffic schemes. Here we develop a life-cycle model to evaluate the whole energy and carbon footprint associated with the transportation infrastructures (including highway, subway and railway systems) built up in Guangzhou City. In addition to a time-series analysis of historical development of these transportation infrastructures over 2003-2017, we set up six scenarios to 2035 to explore the future pathways of enhancing energy and carbon footprints mitigation in urban infrastructure. The results suggest that railways contribute the most of energy and carbon footprint per unit length in average year, followed by subways and highways. The manufacturing phase of materials has the greatest energy and carbon impact across all phases of the life cycle. All three types of transportation infrastructures increased gradually during 2003-2017. As for 2035 scenarios, the energy and carbon footprints of highways will be expected to significantly decrease, while the footprints of both subways and railways will continue to grow, indicating that the latter two technologies in emission reduction are insufficient to make up the increase in engineering. These findings could offer systemic insights into the dynamics of energy and carbon footprint of transportation infrastructures in cities and provide a long-term vision in how to adjust urban transportation policies based on historical trajectories of infrastructure development.

Keywords
urban transportation infrastructure, life-cycle analysis, energy and carbon footprint, Guangzhou City.

Application of cleaner production in a Chinese magnesia refractory material plant
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Abstract
The rapid development of the magnesia refractory industry has caused serious problems of resource and energy waste and environmental pollution. Cleaner Production and Cleaner Production Audit are considered effective tools for energy conservation and emission reduction in the industry. This study presents an application of cleaner production and cleaner production audit in a typical large-scale magnesia raw material production plant in Liaoning, China and the results of their implementation. Through the 7 steps of a cleaner production audit (planning and organization, pre-assessment, assessment, option generation and screening, feasibility analysis, implementation, and maintenance of cleaner production), the resource and energy consumption and environmental emissions of the enterprise are investigated, the key auditing procedures are identified, and the cleaner production opportunities are analyzed. 28 cleaner production options, including raw material and energy substitution, technology improvement, facility maintenance and updates, process optimization and control, waste reutilization, management, and staff training and motivation, have been developed and implemented in a feasible way. After complete implementation of these options, great environmental and economic benefits are expected to be achieved: increased utilization of magnesite tailing powder by 281,000 t per year; annual savings of 25,000 t of magnesite ore; savings of 384,000 kwh of electricity; a 21.7% reduction in magnesite consumption per ton of FM product; improvement of the wastewater utilization rate from 70% to 100%; the removal of dust, SOs, and NOx emissions produced by burning coal or producer gas; savings of 1.066 million USD per year. The results demonstrate that implementing cleaner production can not only bring environmental benefits, but also significant economic gains. Moreover, factory staff have recognized the benefits that cleaner production can bring to the plant, and plan to continue the process. Since there are few studies on the application of cleaner production in the magnesia refractory industry, this paper provides scientific guidelines for its implementation in other similar enterprises, and a theoretical and practical basis for promoting the sustainable development of the industry.

Keywords
Cleaner production (CP), Cleaner production audit (CPA), Magnesia refractory industry, Caustic calcined magnesia (CCM), Dead burned magnesia (DBM), Fused magnesia (FM)

Study on resource recovery of the copper-ferrite waste
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Abstract
Copper-contaminated wastewater, produced in the progress of circuit boards production, was complex and its pH was unstable, which made it difficult to treat. The main methods, including chemical method, ion exchange, electrochemical, etc., were adopted to remove Cu(II) from the wastewater. However, these methods have some shortcomings, such as high operation cost, large quantity of sludge, etc. In view of the above problems, magnetic ferrite (Fe3O4) with excellent magnetic property was proposed to treat copper-contaminated wastewater at 250°C. Then produced the copper-ferrite waste with high toxicity which was harmful to the environment. Thus, the preparation of Fenton-like catalyst by
copper-ferrite waste was proposed. The methods for preparation catalyst were studied. The effect factors, including copper adsorption capacity, reaction temperature and reaction time, on the synthesis of catalyst were discussed. And the structure change and formation mechanism of the catalyst were analyzed. Then the as-prepared catalysts combined with hydrogen peroxide (H₂O₂) were applied to treat the organic wastewater from electronic circuit boards. The influencing factors and the effect of the change of catalyst structure on the Fenton-like reaction were investigated; the kinetic model of organic degradation was established to reveal the mechanism of catalytic oxidation. Finally, the optimum method for the synthesis of copper-ferrite catalyst was obtained.

Keyword
Copper-ferrite waste, resource recovery, copper-containing ferrite catalyst, Fenton-like reaction, copper-contaminated wastewater.

Application of cleaner production in a Chinese magnesia refractory material plant
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Abstract
The rapid development of the magnesia refractory industry has caused serious problems of resource and energy waste and environmental pollution. Cleaner Production and Cleaner Production Audit are considered effective tools for energy conservation and emission reduction in this industry. This study presents an application of cleaner production and cleaner production audit in a typical large-scale magnesia raw material production plant in Liaoning, China and the results of their implementation. Through the 7 steps of a cleaner production audit (planning and organization, pre-assessment, assessment, option generation and screening, feasibility analysis, implementation, and maintenance of cleaner production), the resource and energy consumption and environmental emissions of the enterprise are investigated, the key auditing procedures are identified, and the cleaner production opportunities are analyzed. 28 cleaner production options, including raw material and energy substitution, technology improvement, facility maintenance and updates, process optimization and control, waste utilization, management, and staff training and motivation, have been developed and implemented in a feasible way. After complete implementation of these options, great environmental and economic benefits are expected to be achieved: increased utilization of magnesite tailing powder by 281,000 t per year; annual savings of 25,000 t of magnesite ore; savings of 384,000 kWh of electricity; a 21.7% reduction in magnesite consumption per ton of FM product; improvement of the wastewater utilization rate from 70% to 100%; the removal of dust, SO₂ and NOx emissions produced by burning coal or producer gas; savings of 1.666 million USD per year. The results demonstrate that implementing cleaner production can not only bring huge environmental benefits, but also significant economic gains. Moreover, factory staff have recognized the benefits that cleaner production can bring to the plant, and plan to continue the process. Since there are few studies on the application of cleaner production in the magnesia refractory industry, this paper provides scientific guidelines for its implementation in other similar enterprises, and a theoretical and practical basis for promoting the sustainable development of the industry.

Keyword
Cleaner production (CP), Cleaner production audit (CPA), Magnesia refractory industry, Caustic calcined magnesia (CCM), Dead burned magnesia (DBM), Fused magnesia (FM).

Trans-provincial health impacts of atmospheric mercury emissions in China
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Abstract
Mercury (Hg) exposure poses substantial risks to human health. Investigating a longer chain from economic activities to human health can reveal the sources and critical processes of Hg-related health risks. Thus, we develop a more comprehensive assessment method which is applied to mainland China—the largest global Hg emitter. We present a map of Hg-related health risks in China and estimate that 0.14 points of per-fetus intelligence quotient (IQ) decrements and 7,360 deaths from fatal heart attacks are related to the intake of methylmercury in 2010. This study, for the first time, reveals the significant impacts of interprovincial trade on Hg-related health risks across the whole country. For instance, interprovincial trade induced by final consumption prevents 0.39 × 10⁵~2 points for per-fetus IQ decrements and 94 deaths from fatal heart attacks. These findings highlight the importance of policy decisions in different stages of economic supply chains to reduce Hg-related health risks.

Keyword
Mercury, trade, health impacts, supply chains.
Socioeconomic factors influencing the food-energy-water nexus in China
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Abstract
Food, energy, and water (FEW) are three critical strategic resources for global social and economic development. Taking a holistic perspective of these three resources can benefit the sustainable development. Existing studies have quantified the nexus of the FEW from different perspectives, but the influencing factors of the FEW nexus have not been revealed. This study integrated environmentally-extended multi-regional input-output (EE-MRIO) model with the structural decomposition analysis (SDA) to explore the driving factors of the FEW nexus in China. From the consumption perspective, we decomposed the water withdrawals into five factors: water withdrawal intensity, production input structure, food/energy consumption structure, food/energy consumption level, and population. From the supply viewpoint, we decomposed the food and energy production into driving factors of food and energy production intensity, production output structure, water primary input structure, water primary input level, and population. We uncovered the features of driving factors in all the provinces of China during 2007-2012. FEW-related policy formulation taking inter-provincial consumption and supply behavior into consideration can make contributions to sustainable management of the FEW resources in China.

Keywords
food-energy-water, structural decomposition analysis, driving factors.

Primary Suppliers Driving Atmospheric Mercury Emissions through Global Supply Chains
Jianchuan Qi\textsuperscript{1}, Sai Liang\textsuperscript{1}, Ying Li\textsuperscript{1}, Yumeng Li\textsuperscript{1}, Cuiyang Feng\textsuperscript{1}
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Abstract
The Minamata Convention on Mercury, which came into force in 2017, aims to control mercury-related risks to human beings and ecosystems by reducing anthropogenic mercury (Hg) emissions. Existing studies have identified direct atmospheric Hg emitters and final consumers causing atmospheric Hg emissions but overlooked primary suppliers driving atmospheric Hg emissions through global supply chains. Here, we identify critical primary suppliers and supply-chain paths for global atmospheric Hg emissions in 2015. Results show that China, Indonesia, and India are major primary suppliers causing global atmospheric Hg emissions. Major sectors and critical supply-chain paths from the supply viewpoint are related to resource extraction and power generation.

Findings of this study can support supply-side measures to implement the Minamata Convention on Mercury, such as the optimization of labor and capital input structures and the optimization of product allocation behaviors to downstream producers.

Keywords
mercury, trade, footprint, supply chain, input-output analysis, structural path analysis.

Health assessment of water metabolic system in urban agglomeration based on ecological network analysis
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\textsuperscript{2} School of Architecture Design and Urban Planning, Shenzhen University, Shenzhen, 518060, China;

Abstract
Methods and indicators are desired to be developed to assess the health of water metabolic system in urban agglomeration to mitigate the problems of serious water scarcity and develop holistic policies for integrated urban agglomeration ecological management. In this paper, we first developed an urban agglomeration multiregional input-output (MRIO) table of water flow to quantify the water consumption and exchanges among the economic sectors in urban agglomeration. Then, a flow-based network model was built to simulate the water metabolic system in urban agglomeration by using the systems-oriented method of ecological network analysis (ENA), through which the water consumption and allocation between different sectors via product transactions among different cities can be investigated. Subsequently, the ENA-based indicators were organized in the proposed framework—Vigor-Organization-Resilience-Coordination (VORC)—to assess the health status of water metabolic system, where vigor expresses water consumption intensity among different sectors, organization examines the structure and function of network, resilience measures the efficiency and development capacity of network, and coordination investigates pathways for the mutual relationships between pairwise sectors and the overall symbiosis of the system. The integrated approach was applied into the case study of the Pearl River Delta urban agglomeration.
in China, which can help to analyze the water flows among the economic sectors in an integral perspective, identify the relationships between economic activities, and evaluate the degree of the stability of the whole water metabolic system. It provides a new perspective to understand the health of urban agglomeration ecosystems and a reliable support for the water-related policy making.

**Keywords**
Water metabolism; Ecological Network Analysis; Health assessment; Urban agglomeration.

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**Research on Environmental Benefit Evaluation of Urban Industrial Symbiosis System Based on LCA**

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**Abstract**
Urban industrial symbiosis system is an important mode to promote the development of regional circular economy and the construction of no-waste city in China. Through the internal products and the by-products of industrial systems and urban systems, waste exchange and reuse, the effective use of regional resources can be realized, and it can also reduce waste production and environmental impact. Dalian has a strong industrial base and is also an important shellfish farming area in China. Therefore, taking Dalian as the research object, firstly, the research on the utilization of shellfish resources in Dalian is carried out, and the best way to bring about the utilization of shell resources with the greatest environmental benefits is selected. Then we evaluate the environmental benefits and potential risks of using industrial waste to produce cement instead of traditional methods in the symbiotic system. Finally, the existing symbiotic scenes in Dalian have been identified, and we increased the virtual symbiosis scenarios that can be implemented, constructed the urban industrial symbiosis system in Dalian, and evaluated the environmental benefits of the system by Life Cycle Assessment (LCA). The main results of the study are as follows: (1) Using shells instead of limestone in cement production has better environmental benefits than landfill, replacement of ceramsite fillers in submerged biofilter columns, and replacement of sand as building materials. (2) Using industrial waste to produce cement can effectively reduce the impact of cement production process on the environment, and effectively reduce the resource consumption and environmental emissions caused by industrial waste disposal. It is an environmentally friendly production method. Plan 1, that is, using fly ash to produce cement can bring the highest environmental benefits. (3) The environmental impact value of the symbiotic system is -2.94E-02, which has positive effects on the environment. The type of environmental impact that contributed the most was Waste Solid (WS), followed by Chinese Abiotic Depletion (CADP). The benefits of all symbiotic scenarios were positive for the environment, and scenario 13 (Scrap iron used for steelmaking) brought the greatest environmental benefits.

**Keywords**
urban industrial symbiosis, shell resource utilization, cement plant, industrial waste, life cycle assessment, environmental impact.

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**Environmental regulation, green technology and carbon emissions**

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**Abstract**
Theoretical research shows that green oriented technology has a positive effect on carbon emissions reduction. As the largest developing country and carbon dioxide emitter, China has implemented strict environmental regulation policies to encourage green technology innovation. But do the policies work? And will it be effective in reducing carbon emissions? In this paper, different types of environmental policies are distinguished. Based on the patent classification in the IPC Green Inventory issued by the WIPO, this paper manually collected the panel data of green invention patents in China from 2000 to 2016, and explored the direct and indirect impacts of environmental regulations on green technologies and carbon emissions with two-way fixed effect model and mediation effect model. The results show that China’s green invention patents are growing rapidly, but the scale is small. Market-oriented and public-participated environmental regulation can effectively reduce carbon emissions, while administrative-ordered environmental regulations increase carbon emissions. Further, market-oriented and public-participated environmental regulations have positive incentives for green technology innovation, thereby reducing carbon emissions, while administrative-ordered environmental regulations restrict green technology innovation, thus promoting carbon emissions. China should actively explore market-oriented environmental trading system in the future, and actively guide the public to participate in environmental governance.

**Keywords**
environmental regulation, green technology innovation, carbon emissions, mediation effect model, China.
Using linear alkylbenzenes (LABs) to identify anthropogenic contributions to aquatic pollution in complex ecosystem: case study of Pearl River Delta, China

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Abstract

Identifying contaminants inputted to the environment and tracing anthropogenic contributions from various socio-economic activities are desirable for implementing effective management and remediation strategies. Linear alkylbenzenes (LABs) have been used as molecular markers to identify the potential anthropogenic origins for other organic pollutants with similar physicochemical properties, such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). Linear alkylbenzenes are usually discharged in the environment as residues of commercial detergents and closely related to socio-economic activities during urban development. The different sources of LABs were investigated in this framework, with the use of factor decomposition method and experimental data. The cities located in the Pearl River Delta (PRD) with one of the highest population densities and fastest economic growth rates in China are mainly responsible for production and discharge of aggregated pollutants in the aquatic system. The framework identifed the direct (including urban and rural domestic sewage and industrial wastewater) and indirect contaminant sources (including the external input and output and agricultural irrigation). The results showed that LABs inputted to the environment from socio-economic activities accounted for 36.63 t/yr of Guangdong province and about 1325.3 t/yr of PRD in 2014. Domestic sector contributed 56% of the total LABs discharge. Industry and public service sectors both accounted for 41% of the total. From 2004 to 2014, LABs increased 1568 t and LABs concentration in industry sewage and consumption per capita were the main contributors to the increase of LABs. The sources of other organic pollutants will be discussed by applying the framework and comparing with the percentage of LABs. Identification of environmental pollution liability is an important part of integrated pollution control in complex ecosystem. The current research provides theoretical support and a database for the formulation of policies leading to regional organic pollutant reduction and remediation of pollution.

Keywords
organic pollutants, Metabolism of cities, source-sink relationship, spatial difference simulation.

Assessing the ecological costs of small hydropower in China: A hybrid Eco-LCA model

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Abstract

After a long-time intensive development of small hydropower (SHP) in China, the resulting ecosystem degradation such as river drying-up aroused extensive attention. Besides, its development also consumes substantial resources, and then exerts disturbances to other ecosystems indirectly due to the upstream production of consumed resources, causing ecosystem services (ES) loss in a larger scale. The life-cycle ecological costs including renewable and nonrenewable resources consumption as well as induced ES loss involved in SHP should be evaluated to achieve true sustainable development. This paper proposed a hybrid Eco-LCA model by combining an economic input-output analysis and energy analysis, with concrete illustration by a case study of a SHP plant in Guizhou Province of China. It is revealed that the life-cycle ecological costs of the case plant totaled 9.24E+18 seJ to produce 1.06E+14 J of electricity. The direct and indirect ES loss due to the construction and operation of the plant, i.e., local ES loss due to the occupation of forest by hydraulic structure and river drying-up, and virtual ES loss in purchased resources, respectively, accounts for 33.22% of total ecological costs. It nearly equals to the input of renewable resources, which mainly refers to the river geopotential energy. Nonrenewable resources including local construction minerals and purchased inputs comprise 29.15% of the total costs. The indirect ES loss in these purchased inputs amounts to 2.74E+17 sej, of which the ES loss due to the use of wood products accounted for the majority because of the high ES loss intensity of the forestry sector. Moreover, the total ecological costs of the plant could decrease to 6.87E+18 sej if downstream river drying-up is avoided. In that case, the proportion of renewable resources in the total costs could achieve 50.68%. Thus to minimize the life-cycle ecological costs, it is very critical to guarantee downstream environmental flows during the operation phase. Using construction materials with low ecological costs is also an alternative to promote the environmental-friendly development of SHP.

Keywords
small hydropower, ecological costs, input-output analysis, energy analysis.
Complex Network Simulation of Forest Network Spatial Pattern in Pearl River Delta

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Abstract

Forest network-construction uses for the method and model with the scale-free features of complex network theory based on random graph theory and dynamic network nodes which show a power-law distribution phenomenon. The model is suitable for ecological disturbance by larger ecological landscape Pearl River Delta consistent recovery. Remote sensing and GIS spatial data are available through the latest forest patches. A standard scale-free network node distribution model calculates the area of forest network’s power-law distribution parameter value size. The recent existing forest polygons which are defined as nodes can compute the network nodes decaying index value of the network’s degree distribution. The parameters of forest network are picked up then make a spatial transition to GIS real world models. Hence the connection is automatically generated by minimizing the ecological corridor by the least cost rule between the near nodes. Based on scale-free network node distribution requirements, select the number compared with less, a huge point of aggregation as a future forest planning network’s main node, and put them with the existing node sequence comparison. By this theory, the forest ecological projects in the past avoid being fragmented, scattered disorderly phenomena. The previous regular forest networks can be reduced the required forest planting costs by this method. For ecological restoration of tropical and subtropical in south China areas, it will provide an effective method for the forest entering city project guidance and demonstration with other ecological networks (water, climate network, etc.) for networking a standard and base datum.

Keywords

landscape, ecology vulnerability, ecology simulation.

Source or Sink: the Role of Biological Processes on pCO₂

Dynamics in the Pearl River Estuary, China

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Abstract

Estuaries and other near-shore ecosystems are considered net heterotrophic environments, acting as a source of CO₂ to the atmosphere and balancing the global net CO₂ uptake by continental shelves. Net heterotrophy promotes the emission of CO₂ to the atmosphere, with global emission from estuarine waters being significant for global CO₂ budgets. However, the role of biological processes on pCO₂ dynamics and emission of CO₂ in estuaries has not been enough understood. Previous researches had demonstrated that the pCO₂ levels and seasonality can be mainly controlled by net ecosystem production while the exchange of CO₂ with the atmosphere has a minor role in pCO₂ dynamics.

To explore the role of biological processes on pCO₂ dynamics, our study firstly analyzed the spatial-temporal variations in CO₂ fluxes from biological processes of China’s Pearl River Estuary from 2018 to 2019. Meanwhile, spatial-temporal variations of pCO₂ and total CO₂ fluxes were analyzed. Aquatic metabolism was estimated using Odum’s open water dissolved oxygen methods and used to represent the production and absorption of CO₂. Net ecosystem production was used to represent the CO₂ flux from biological activities.

Our metabolism results showed the heterotrophy dominated in the Pearl River Estuary. Biological activities led to a source for atmospheric CO₂ and an increase in pCO₂. There were also significantly seasonal and spatial variations in aquatic metabolism and pCO₂ among Huimen, Jiaomen, and Hongqigui of Pearl River Estuary. Gross primary production rate and ecosystem respiration rate in spring was more than that in other seasons. Net ecosystem production in Huimen was significant lower than that in Jiaomen and Hongqigui, which led to a bigger CO₂ emission from biological processes per unit area in Huimen. At last, annual CO₂ release from biological processes was calculated and compared with fluxes of CO₂ in the Pearl River Estuary.

Keywords

Net ecosystem production, Biological processes, Net heterotrophy, pCO₂, Pearl River Estuary.
Recovery of P and K from urine through electrochemical magnesium dosage

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Abstract

P and K can be recovered simultaneously from urine via the precipitation of magnesium potassium phosphate hexahydrate (MPP) (Wilenach et al., 2007; Xu et al., 2011). This technique was extremely important for countries lack of phosphate and potash, two important but non-renewable mineral resources. However, co-precipitation of magnesium sodium phosphate heptahydrate (MSP) has been considered as a bottleneck for further application of this process as it reduced the theoretical efficiency of the K recovery (Xu et al., 2011). Therefore, this study proposed a novel approach to initiate the precipitation process with electrochemical Mg dosing to reduce the addition of NaOH.

Process characteristics, including nutrient recovery efficiency, current efficiency, and energy consumption, were investigated via conducting batch experiments. Synthetic urine was prepared according to Xu et al. (2011). Its initial pH was adjusted to 8 using NaOH, and then it was further diluted 5 times in deionized water before being used in the experiments. Batch experiments were conducted in an electrocoagulation reactor (500 × 70 × 310 mm) stirred with an electromagnetic stirrer. A pair of Mg plates (200 × 50 × 10 mm) was employed as the anode and the cathode, and they were connected by a direct current power supply with a digital amperemeter and a digital voltmeter. 500 mL of the diluted synthetic urine was filled to the reactor and the electrode gap was fixed at 2 cm. Each experiment lasted 15 min with a mixing speed of 10 rpm. All samples were filtered with 0.45 μm filters, and then analyzed on concentrations of Mg, K, Na, and phosphate.

Results showed that the P recovery efficiency increased all through the operating time while the maximum efficiency of K recovery was achieved at 6 min (Fig. 1). Releasing of more Mg2+ and higher pH than 11 may lead to the decreasing of the K recovery after the optimized time. Calculations based on measurements showed that the MSP/MPP ratio in the precipitates was only 0.04, much lower than the reported value of 0.71 using resolvable MgCl2·6H2O (Xu et al., 2012). In addition, the current efficiency decreased, being confirmed by the passivation of the Mg anode. Efficiencies of the nutrient recovery from urine under different operating parameter are shown in Table 1. Higher current density and area-volume ratio increased the P recovery. However, their effects on the K recovery cannot be directly compared as the optimized time point was not easy to catch. The optimized time for the K recovery extended at lower current density or lower area-volume ratio. Higher efficiency of the K recovery could be achieved at longer operating time than 15 min. Another experiment was further conducted under lower current density (5 mA·cm⁻²) and lower area-volume ratio (9.4 m⁻¹). The solution pH was maintained from 10.8 to 11.0 via dosing 1 M HCl after an operating time of 12 min. The maximum recovery efficiency of P and K was achieved at 30 min, which was 96% and 38%, respectively. The new approach improved the K recovery by 41%, compared with that using resolvable Mg source. The results indicate that the MPP precipitation induced with electrochemical Mg dosing is an efficient method for the simultaneous recovery of P and K from urine to yield multi-nutrient products.

Keywords

Electrocoagulation, Nutrient recovery, Struvite, Urine, Potassium.

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Complete recycle of ammonium, phosphate and potassium from urine into slow-release fertilizers using wood-waste biochar

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Abstract

Sustainability in waste and wastewater treatment is currently drawing extensive attention. The demand of chemical fertilizers rapidly increases due to the growing population and food supply.

However, nutrients in waste and wastewater are commonly considered as pollutants due to their negative effect on aquatic environment. This brings unsustainability to the development of human society. This study employed Mg-modified biochar yielded from wood waste to recycle ammonium, phosphate and potassium from human urine to a value-added fertilizer product. Crystals on the nutrients-loaded biochar surface were confirmed to be struvite (MgNH4PO4·6H2O) and struvite-K (MgKPO4·6H2O) based on analysis using a Scanning Electron Microscope/Energy Dispersive X-ray Spectroscopy and an X-ray Diffractometer. Thus, the precipitation of struvite-type compounds on the biochar surface was the dominating mechanism for the nutrients removal. The preferred pH ranges for the removal of ammonium and phosphate was 7–9 while that for the removal of phosphate and potassium was 8–11. Particularly, the concentration of phosphate was
a limiting factor for the removal of ammonium and potassium. This corresponds to the precipitation mechanism on the biochar surface. The relatively low concentration of phosphate in the urine solutions limited the removal of ammonium and potassium although most of phosphate could be removed. Further, all the three nutrient elements were loaded on the biochar via controlling the residual ammonium concentration in the stripped urine. The nutrient-enriched biochar presented slow-release characteristics of magnesium, ammonium, phosphate and potassium. Therefore, using MgO-biochar derived from garden waste can effectively recycle ammonium, phosphate and potassium to biochar-based slow-release fertilizers, demonstrating a sustainable approach for the disposal of garden waste and nutrients removal from wastewater.

**Keywords**

Nutrients removal; Struvite precipitation; Biochar; Urine; Sustainability.

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**A reservoir operation method considering uncertainty of inflow: using the bayesian network**

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**Abstract**

The ignoring of runoff uncertainty in reservoir ecological operation make the future reservoir operation difficult. In order to deal with this problem, we proposed a reservoir operation method using the Bayesian Network (BN) method. BN is trained and verified using the results of a reservoir operation optimization model, which optimizes monthly release and supply water and minimize the supply water shortage and hydrological alteration degree. The trained BN provides the probability distribution functions of reservoirs’ releases for each set of input data (monthly inflows and reservoir shortages at the beginning of the month) and an operating policy can be searched and fixed quickly and accurately on it according to the forecasted inflow. This method was applied to long-term optimization of the Tanghe reservoir in China’s Tang river basin. The results demonstrate that this approach is suitable for establishing the reservoir operation rules with taking inflow uncertainty into account.

**Keywords**

Bayesian Networks(BNs); reservoir operation; optimization; uncertainty.

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**A methodological review: quantitative methods of environmental pollutants on economic, ecological and resource losses**

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**Abstract**

Environmental pollution has caused great damage to the society and human life. The damage caused by environmental pollution can be expressed in money or other forms, that is, the loss of environmental pollution quantified measurement, which is an important and complex issue. Its importance lies in that it enables people to have a quantitative understanding of the severity degree of environmental pollution and the effectiveness of environmental policies, and also provides information support for the government to formulate or verify relevant policies. Considering the different perspectives of human and nature, the quantitative measurement of environmental pollution loss can be classified as economic loss, ecological loss and resource loss.

The most important part of the economic loss is the calculation of the loss of human health. Among all the studies on the relationship between environment and health, the study about the impact of air pollution on health is the most common. At present, quantification of health loss caused by air pollutant mainly involves Environmental Epidemiology and Environmental Toxicology, which can be divided into chronic effects and acute effects according to exposure time. Representative methods such as cohort study, is regarded as the evaluation of long-term exposure to people health effects of air pollution is relatively ideal method, but the air pollution damage to people health is often subclinical changes in individual and pollutant and its metabolites in the body of excess load, from the level of people consider health losses while facilitating economic loss analysis, but can only reflect the people health status in general. Other methods such as time series, considered a certain lag of air pollution in short-term can affect the health of individuals, but as a result of air pollution, the influence of meteorological factors on population health is usually a lag, so requires time series model to reflect the effect not only on the change of the independent variable dimension, but also reflect the effects of time structure (that is, the exposure-response relationship). In addition to the loss of human health, the economic loss caused by environmental pollutants also includes the losses of infrastructure, ecology and natural resources, but the current calculation method is relatively monotonous.
In terms of ecological and resource losses, economic means have ignored the scarcity of natural resources in the quantification of ecological losses, which has endangered the productivity level that economic development needs to maintain. Eco-indicator 99 is a more comprehensive life cycle evaluation method for quantifying ecological and resource losses. Eco-indicator 99 uses different species groups as representatives of the entire ecosystem and different levels to determine impacts, but this means that there is no uniform unit of measurement as in calculating economic losses. Other methods developed on the basis of eco-indicator 99, such as IMPAC2002+ and ReCiPe2016, do not solve this problem in essence. Energy theory is a concept proposed by H.T. Odum in 1987, a famous American ecologist. Energy theory converts resources, products or services into a uniform unit of measurement so that different energies can be compared with each other.

To sum up, this paper lists several kinds of pollution and losses, evaluating different points of view in quantitative ways or methods, and to make a comparison of advantages and disadvantages between various methods, and then review several practical cases of the above methods in China or other countries in recent years, finally came to the conclusion that is in order to provide reference for the related researchers.

**Keywords**

Environmental Pollution; Economical Loss; Human Health; Ecological Loss; Resource Loss.

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**Resource, recycling and reusing the metallurgy slag**

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**Abstract**

Along with the rapid development of metallurgy industry in China, metallurgy slags such as steel slag, dust, non-ferrous slags and so on, increase rapidly each year, but only a tiny part of them are recycling and most of them are dropped. This not only lead to waste of the valuable resource that contained in the Solid Waste, but also caused enormous pollution in the natural environment. In order to make fully use of the valuable resource composition in the solid waste, some new process for recycling metallurgy slags have been introduced in this work.

**Keywords**

Steel slag; Non-ferrous slags; EAF dust; Recycling; Comprehensive.

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**Ecosystem Valuation Services and Prominence of Monetization: A Preliminary Illustration**

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**Abstract**

Given it’s complex and indirect nature of the benefits and costs of the ecosystem valuation services and detaching the bond of non-counting services, make it interesting. Among several other research questions, the most simple yet significant question lies in the sense that “why we need ecosystem valuations services and their monetization in current era?” Such basic knowledge certainly has led many services to start get counted in many countries, especially in developed countries. China is also one among those countries who are challenging themselves to internalize the externalitys of ecosystem and put the price tag on nature so that the open-access nature, and free-riding of ecosystem services should be minimized. This paper presents a review case study on the preliminary knowledge and prominence considering the ecosystem valuation services and their monetization in China. The research questions include the following: i) why we need ecosystem valuation services? ii) How ecosystem is valued and monetized? iii) What methods exist and how that can be utilized? We used simple systematic review method and generalized the estimations by using some proxy data of another situation. Besides, in this paper, we have utilized the Market Price Method in order to understand the monetization system and used a substitution example on forest regulating services. Interestingly this study help resulting that there are two major types of ecosystem valuation services monetization (estimation/counting) methods, i.e., dollar-based methods and non-dollar-based methods. They are also sometimes known as direct methods and indirect methods depending on the situation and nature of the capital estimation. Under dollar-based ecosystem services, a total of eight methods are categorized which can be utilized as per the nature of the data, study area, and the market of ecosystem services. Furthermore, we also found that ecosystem services are possible to monetize and estimate their market values or at least economic values using shadow prices. Market Price based method revealed that such method/technique can be applied on multiple ecosystem services such as fishery, wood, forests, water, etc. Hence, this is one of the comparative advantage of this method over rest of the ecosystem.
valuation methods. Last but not least, regardless of the region, and ecosystem services, these methods can be applied to monetize the ecosystem valuation services provided the correct information is available and appropriate method is applied. As a suggestion, nothing can be better than this to strengthen the United Nations Sustainable Development Goals (SDGs) and China is fully committed to do that.

Keywords
Ecosystem valuation services, Economic value, Market price method, Shadow pricing, Sustainable development goals.

Sustainability assessment of rice production systems in different nitrogen fertilizer treatments by using energy approaches
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Abstract
Urea and a novel controlled released nitrogen fertilizer (CRNF) are used to increase rice production. To analysis the differences of productivity and sustainability between two types of nitrogen fertilizer, field experiment was conducted in Sichuan province, an important key grain area in China. Urea and CRNF were used in this study, four treatments were as follows: no fertilizer (CK), conventional fertilization (Urea), controlled released nitrogen fertilizer (CRNF), Urea+CRNF. Using the data from filed experiments and investigation. Greenhouse gas emission and ammonia volatilization were measured during the rice plantation. Quantifying the indices included grain outputs (in joules), energy renewability ratio (R%), unit energy value (UEV), environmental loading ratio (ELR), energy yield ratio (EYR), and energy sustainability index (ESI). Total energy supporting in the four systems (CK, Urea, CRNF and Urea+CRNF) were 4.17E+15, 7.13E+15, 7.15E+15 and 7.14E+15 in 1971, 1972, 1973 respectively. Grain output showed that CRNF could greatly increase rice yield. Compared with Urea, rice production increased by 11.40% and 7.96% in CRNF and Urea+CRNF respectively. However, the R% indicated that 75.44%, 75.12% and 75.06% of the total energy input was obtained by nonrenewable resources in Urea, CRNF and Urea+CRNF respectively. It revealed that fertilizer would bring part of environmental pressure of rice production system. EYR results demonstrated that the highest ability of CK the rice production process to exploit local resources, in other words, it lived on the mercy of the natural elements. Therein, the other three treatments accounted for the similar dependency on imported resources while higher environmental load was brought in the three fertilizer treatments. Because of the higher ecosystem stress, ELR of the three fertilizer treatments were about 2 times of CK. Under this circumstance, the higher ESI value of CK was indicative of undeveloped agricultural while the lower ESI showed a highly developed consumer-oriented agricultural. ELR, EYR and ESI showed the contradiction between agricultural development and environmental protection. It also revealed the importance to keep the balance between development and environment in rice production. Analysis of the composition of purchased inputs indicated that fertilizer accounted for 59.76%, 60.42% and 60.32% in Urea, CRNF and Urea+CRNF respectively. Data of ammonia volatilization showed that CRNF and Urea+CRNF could obviously decreased by 84.37% and 68.95% respectively compared with Urea. It revealed that the key to improving sustainability was not only to reduce the amount of nitrogen fertilizer consumption but also improve the utilization rate.

Such findings can provide valuable fertilizer utilization insights so that more appropriate nitrogen fertilizer type selection can be considered in rice production system.

Keywords
Controlled released nitrogen fertilizer; Urea; Rice production; Energy; Sustainability.

A Review on Seafood-Water-Energy Nexus: An aquaculture system with Energy Efficiency, low wastewater and Food loss
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Abstract
The food-energy-water nexus means that water, energy and food security are linked to each other which results in effecting the other two with actions taken in any one area. The food-energy-water are necessary to have a sustainable development of economy and environment. The nexus approach supports efficient use of resources for a sustainable growth. Existing nexus studies help in understanding of the links between food, energy and water sectors. However, until now the main researches on nexus approaches only focus on agricultural food or other animal origin food, and few studies are related on seafood. Fisheries is a rapidly growing food sector worldwide, due to its high nutritional abilities it is advised to double the seafood consumption, but the over fishing has resulted in a decline of wild caught harvest. To fulfill the increasing demand for seafood, aquaculture is being used. With the rapid development of aquaculture, the requirement for energy and water
use increases, varying by species and production systems. It has become a matter of concern for researchers and governments in the present time. This study is driven by un economical use of energy and water resources that leads to loss of resources, money, and a rich protein source; focuses on problems; inefficient use of water and energy resources in the production sector of the seafood supply chain and intends to fill the information gaps regarding energy and water use in the seafood production sector and to identify strategies to have an improved production of seafood with a reduced amount of waste. This paper reviews the influencing factors for energy consumption and wastewater in an aquaculture system. Results show that it is important to develop aquaculture systems which would be under ecological capacity and current technologies should be improved along with enhanced organizational practices and proper site selection to achieve sustainable fish stocks.

Keywords
seafood Nexus, Energy consumption, Waste water, Food loss.

Weather Variability Resilience: Farmers’ Decision
Factors for Irrigation Adoption and it’s Significant to Rice Yield in Tanzania

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Abstract

Rural farmers are facing different challenges resulting from climate change and weather variability which have posed threats in crops production and productivity. Small scale farmers try to cope with the prevailing situations by adopting different mechanisms including adopting irrigation services. This study seeks to (i) determine factors influencing rice farmers’ decision to adopt irrigation technology, and (ii) find out the significant contribution of irrigation to rice yields in the Mbeya Region of Tanzania. Data collected through structured questionnaires, interviews, and focus discussion. Data analyses were performed by descriptive statistics, Logistic regression, and Ordinary Least Square regression by STATA software version 13. The descriptive statistics characterized households’ socio-demographic and economic characteristics. Logistic regression results affirmed that households’ education, labour size, meteorological Information, access to financial services, extension services and previous farm outputs significantly influenced irrigation adoption by farmers. Results from Ordinary Least Square regression confirmed that irrigation significantly contributed to rice yield at P<0.05 level. The study recommends the adoption of irrigation technology in Tanzania as means of coping-strategy to the negative impact of Climate change and weather variations. Finally, authors developed the model for irrigation adoption estimation which could be used for rice yield forecasting.

Keywords
weather; yield; irrigation; logistic regression; ordinary regression; Tanzania.

Identifying characteristics that influence the implementation of energy recovery from MSW in Brazilian municipalities

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Abstract

The requirement to comply with regulation and evolve solutions on waste management encounters support on the use of WtE technologies in different countries. In Brazil, the variety of regions, states and municipalities characteristics are responsible to influence public policies on waste management, due to municipality’s different conditions. Thus, it is important to consider their particularities to improve decisions towards more efficient public policies fostering WtE applications. Brazilian municipalities have a significant portion of population in the urban area, concentrated mainly in the South and Southeast region, where is also concentrated the technologies for energy recovery from MSW, and which contains the majority of the country’s population living in large developed areas of the country. In this sense, the study indicates that, despite the relevance of the number of inhabitants and GDP per capita indexes, it does not constitute the only variables, which influences WtE adoption in the country, principally in small and very small municipalities. For these
reasons, the analyzes identified at least one parameter for territorial, technical, social, economic and environmental variables to be considered on WtE adoption in Brazil, with the aim to facilitate public policies decisions on waste management and disposal, considering the energy recovery from waste solution.

**Keywords**

Waste management, energy recovery, WtE, Brazil, small municipalities.

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**Household Demand Consumption Patterns in Rural Cambodia:**

**A two-stage ELES-AIDS Model**

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**Abstract**

A two-stage budgeting ELES-AIDS system is used to evaluate household demand consumption for commodities such as food, health, education, clothing, living, transportation, fuel, and equipment in rural Cambodia. Results indicate that demand is price-inelastic for transportation, living, clothing, education, health, and other commodities, and own-price elasticities range from 0.75 to 0.14. Income elasticity is lower for a living and greater for equipment, clothing & health. Expenditure elasticities of rice, maize, potato, eggs, and vegetables are less than one, implying that all necessary commodities such as meat, fruit, and drinks are significantly greater than one, thus, categorizing them as luxury commodities.

**Keywords**

Two-stage budgeting ELES-AIDS models, Households Food Consumption, Demand elasticity.

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**Multi-basin scale ecological network model for evaluating evolution of water resources systems toward sustainable water use**

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**Abstract**

Complexity of water use activities is of critical concern when evaluating the development of water use systems, and which created the necessity to apply a systematic approach of ecological network analysis (ENA) in water resources systems. However, there is still a broad knowledge gap about the analysis of water transfer activities among river basins in a view to treat the multi river basins as a whole. In this research, given water transfer projects that have been conducted among river basins in China, a multi-basin ecological network model was developed for evaluating the evolution of basins of Huang River, Huai River and Hai River (the HHH basins) from 2008 to 2017. By system-level and information analyzing, characteristics including total system throughput (TST), ascendency (A and a), redundancy (R and r), overhead (O and o) and development capacity (C) show a steady trend of change and which indicate a tiny variation of network structure. Also, the results of a suggest that the network structure is characterized by a better ability to transfer material than to be against the external interference. Using a network utility matrix in network functional analysis, 4 pairs of compartments including Rivers, Production & Resident Living, Environment and Water Purification System (WPS) were chosen to be compared in order to gain the ecological relationships between each two of three sub-basins. As part of water in sub-basins of Hai and Huai is depended on water supply from Huang River, ecological relationships between basin of Huang River and the other two sub-basins are similar and the pressures on environmental flow in basins of Huai and Hai are more significant than that of in the basin of Huang River. Based on analyses, some effective measures toward the sustainable water use under the serious water shortage were put forward.

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**Food-Water-Energy Nexus: seafood production in Liaoning Province, China**

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Abstract

The Food–Water–Energy Nexus analyses integrate three factors in an interconnected system, considering the relationships among them and human activities impacts. Energy, food, and water underpin sustainable development and are inextricably linked: agriculture is the largest consumer (70%) of freshwater resources; one third of energy used globally is expanded on food production and supply; and all three are impacted by population growth, economic development, urbanization, growing demand, climate change and resource degradation. Developing sustainable consumption and production patterns has been selected as one of the 2030 Sustainable Development Goals for both China and United Nations. Seafood is recognized as comparing favorably with other proteins when it comes to environmental impacts. China’s fishery production has continued to increase since 1978 and now China is the largest producer of seafood contributing 69.012 MMT to global production. China is only major fishery country whose aquaculture output surpasses its catch output. However, the main researches on nexus focused on agricultural and livestock products with big-scale, and few studies related to seafood and regional-scale. Liaoning province is one of the eight top seafood-producing province in the country; and the most important industrial bases in China which covers a broad range of industries, such as machinery, electronics, metal refining, petroleum, chemical industries, construction materials, coal and so on. However, the problem of resource scarcity and environmental pollution also arise along the economic growth in Liaoning affecting on seafood condition. This study is driven by inefficient use of water and energy resources that leads to loss of food, resource, money; and to identify strategies for local government and industry to improve production and normalize the amount of seafood under ecological capacity with decreased waste. This study overview seawater aquatic products and freshwater aquatic products such as fish; shrimp, prawns and crabs; shellfish; algae and others in Liaoning province during 2003-2010; study of resources efficient improvement and environmental impact. Results can assist with coherent policymaking and management to achieve efficiency and sustainability in the seafood sector.

Keywords

seafood, nexus, wastewater, energy, Liaoning province.

The application and evaluation of reclaimed water to urban landscape water supplement in Beijing, the capital of China

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Abstract

Water resource plays an essential role for the sustainable development of society and economy. Due to the declining availability of freshwater resources, reclaimed water has become increasing prominent as an alternative water resource. More and more reclaimed water is used to supplement urban rivers and lakes. But the huge supply of reclaimed water in the urban landscape water led to lots of ecological and environment problems. After a large number of literature review and site tests in Beijing, the status of wastewater treatment and reclaimed water utilization was proposed and a set of measures and technologies for maintaining the quality and quantity of reclaimed water to urban landscape water supplement were implemented. In this study, we developed optimization model which including 20 indexes, 7 criteria, 3 systems of environment factors. Use this model to evaluate the performance technical management and social economy function of reclaimed water engineering technologies. Based on the study results, the suitable technologies for the water quality, ecosystem and economic investment was recommended.

Clean Production Project of Gaobeidian Wastewater Treatment Plant of Beijing Drainage Group Co., Ltd.

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Abstract

Clean production project of Gaobeidian Wastewater Treatment Plant consists of 22 low-cost programs and 6 medium-high fee renovation project. Low-cost programs include raw material energy conservation and replacement, product optimization, equipment maintenance and renewal, process optimization control, technical process improvement, employee training, management optimization and waste reduction and recycling. The specific application technology of medium-high fee scheme are as follows: (i) Update the inlet pump, which use high efficiency motor and equipped with a set of medium voltage frequency conversion cabinet. The pump will effectively control the stability of the pump pit liquid level and steady pumping flow, reduce the pump power consumption. (a) Optimized operation of sand removal
system by replaces the sand water separator and automatically controlled gas-water ratio. (3) Install sludge concentration meter in the primary settling tank to achieve effective monitoring sludge concentration to improve sludge discharge efficiency and achieve stable high-concentration sludge discharge. (4) On the basis of the original PLC control system, the control mode is changed from manual to automatic control through the newly developed software, liquid level meter and online dissolved oxygen meter, reflecting the water volume and dissolved oxygen in real time, thereby realizing the refined operation of the aeration system. (5) The chemical dephosphorization dosing pump is upgrade to realize the real-time adjustment of the dosage. (6) Fine control of residual sludge pump. In order to accurately calculate the amount of sludge remaining in the sludge, scientific use of the sludge age control biological system is carried out, and it is proposed to fine control the remaining sludge pump.

The 28 programs developed in this clean production are applicable to most of the current sewage treatment plants, including upgrading and upgrading, energy saving, and green recycling.

Assessment of the flow regimes alteration in typical spawning ground: a case study of the Pearl River

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Abstract

The spawning ground with special characteristics of flow regimes is so important for the natural reproduction of fish. However, in recent years, due to the human influences, the natural flow regimes of fish spawning ground have been significantly altered, which puts direct threats into the germplasm resources of fish. In order to effectively alleviate the influences, it is necessary to understand the flow regimes alterations in all aspects, including flow frequency, timing, magnitude, duration, and rate of change. In this study, we try to comprehensively assess the flow regime alterations of spawning ground from two levels (indicator and overall flow regime). Firstly, at the indicator level, a set of 32 Indicators of Hydrologic Alteration (IHAs) is adopted, and the characteristics of each indicator are detailed analyzed based on statistical theory. Then, the Mann-Kendall method is used to check the trend of indicators. Finally, at the overall flow regime level, a Range of Variability Approach (RVA) and a revised RVA are applied to calculate the overall flow regime alterations of the fish spawning ground. The Dongta spawning ground located in the Pearl River is used as case study. The results showed that the magnitude and duration of annual maximum water conditions, timing of annual extreme minimum water condition, and mean duration of low pulses within each year were greatly altered. The Mann-Kendall trend test results showed that during 1995 to 2005, the trends of IHAs were totally changed. And the overall regime alteration of the Dongta spawning ground was 30% (low alteration).

Keywords

spawning ground; indicators of hydrologic alteration; Mann-Kendall method; flow regime.

Evaluating the stormwater quantity and quality control efficiency of low-impact development practices at multiple temporal scales

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Abstract

The assessment of low-impact development (LID) practices at catchment scale could provide valuable suggestions for stormwater management. In the present study, the control efficiency of LID practices for runoff volume, peak flow and NPS loads at both the annual and event scales was evaluated based on modelling. The study catchment, with total area of 58ha, could contribute 6.25–8.39 t chemical oxygen demand (COD) and 0.86–0.41 t NH3-N as NPS loads per year. Based on the quantification at event scale, the pollution risk of heavy rain, torrential rain and heavy rainfall should be prioritized in water quality management decisions. At the annual scale, the reduction rate increased with increasing implementation levels of LID practices. At the rainfall event scale, for most events, runoff volume, peak flow and pollution load decreased with increasing LID types and proportion. However, the controlling efficiency of LID practices for moderate and light rain events was not always better than that for heavy rain and above levels. Negative values of the reduction rate were found for particular events. The characteristics of the antecedent and current events (rainfall depth,
rainfall intensity and event hyetograph) and the definition of minimum inter-event time (MIT) would all affect the evaluation of LID performance.

Keywords
PCSWMM; non-point source pollution; LID practices; control efficiency; annual scale; rainfall event scale.

Does energy transition improve air quality: evidences from clean heating pilot project in China
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Abstract
Rural household coal use for heating poses severe threat to ambient air pollution and human health. China has implemented clean heating pilot project by energy transition of “coal-to-electricity/gas” in 2017. However, the impacts of CHP project and the dynamic changes have not been well quantified. Based on a daily-monitoring panel data covering 35 pilot cities, we conducted a difference-in-differences (DID) model to identify whether CHP project is effective for air quality or not. The results showed that the emissions of AQI, PM2.5, NOX, and SO2 decreased by 20.4%, 18.6%, 34.3%, and 68.4%, respectively, and these decreases in Western China were greater than Eastern China except for SO2. When the variables weather, holiday, gross domestic product, ratio of the secondary industry, income level, and environmental expenditure are controlled, these conclusions are also robust. In addition, parallel trend and placebo test were used to confirm the reliability of the conducted DID model. Finally, some policy recommendations are made for rural scale energy transition, including reforming the electricity/gas price through advanced technology and subsidy mechanism on account of regional inequality.

Keywords
energy transition; heating; air quality; DID; WCHD policy.

Evaluation and Empirical Study of Typical Lead Substitution Technique of Coatings Industry in China
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Beijing 100029, China

Abstract
Lead paint is a major source of lead exposure, globally, posing serious risks to human health and the environment. To tackle the problem of lead exposure, UN Environment along with the international communities, have taken a series of global efforts to phase out lead paint. This paper analyzes the development status of the international and domestic coating industry, outlines the progress of lead substitution techniques, takes typical paint as researching object to identify the main sources of lead in paints and clarify the technical direction for lead substitution. The paper establishes a list for lead-free substitution techniques of coating industry, including lead-free pigments and driers, applies AHP-FCE method to test the paint product performance characteristic, cost-effectiveness and environmental impacts of series of alternative techniques listed. The paper recommends the best available techniques for lead-free substitution of coating industry, and carries out empirical research for pilot demonstration in China.

Keywords
lead exposure; lead in paint; lead-free substitution; green coating.

Research on the Guideline of Whole Process Pollution Prevention and Control for the Furniture Manufacturing Industry
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Abstract

Furniture manufacturing is one of the key industries of VOCs pollution prevention and control in China. Based on the thoroughly survey of the status quo of air pollution control of China’s furniture manufacturing industry through field investigation and test analysis, the article identifies the air pollution sections and nodes and polluting characteristics of the furniture manufacturing industry. By analyzing the pollution reduction potential from the aspects of alternative raw and auxiliary materials (coatings, adhesives, etc.), process operation (sanding, painting, etc.) optimization, pollutants collection and treatment, and environmental management, and proposing solutions in a targeted manner, the article formulates a guideline of whole process pollution prevention and control. This guideline provides an effective solution for the enterprise to achieve whole process pollution prevention and control, and also provides reference model for other industries.

Keywords

Furniture manufacturing, Pollution prevention and control, Whole production process.

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Assessment and Empirical Study of Best Available Techniques (BAT) for Integrated Pollution Prevention and Control for the Tanning Industry of China

--Based on big data of China’s pollutant discharge permit system


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Abstract

The progress of the pollution prevention and control techniques of tanning industry is briefly summarized in this paper. Based on the big data information of China’s pollutant discharge permit system, the article makes statistical analysis of the application of pollution prevention and control techniques of more than 400 tanneries, which forms the alternative techniques list. The evaluation index system and weights of indicators are defined by using the method of frequency statistics, theoretical analysis, Delphi and AHP, and combined with the assessment method of Grey Relation Analysis (GRA), 10 sets of BAT for the tanning industry of China are further proposed, which are applicable for various types of tanneries and different discharge standards. At last, the applicability of proposed BAT is verified through an empirical study by using the compliance emission data from the pollutant discharge permit system.

Keywords

BAT, Tanning industry, Pollutant discharge permit, Big data.

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The safety evaluation of water resources based on DPSIRM conceptual framework in karst region

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Abstract

Aiming at the problems existing in the safety evaluation of water resources, such as partial evaluation indexes, the omission of single index membership information and subjectivity problem of determining weight, In a typical karst area-Guizhou province as an example, combining with the characteristics of water resources in karst region, based on conceptual framework of driving force-pressure-state-impact-response-management (DPSIRM) to build evaluation index system of water resources security, with the help of grey-set pair model to make quantitative evaluation of Water security of Guizhou province in 2005–2005. The results show that: the water security in Guizhou in 2005 and 2006 in the criticality safety state, 2007–2012 in a safe state, water security in Guizhou to present the overall good posture. the
state of water resources and water resources management were the important factors affecting the safety of water resources. Continued to adjust the economic structure and transformation of the mode of growth at the same time, improve the utilization efficiency of water resources, increase investment in infrastructure construction of water resources, strengthening the construction of water resources management system and improve the implementation of water resources management system, these were the fundamental guarantee of the water security in Guizhou; The applicability of the evaluation model and index system was stronger, the evaluation results more objective, provided a new perspective and a new method for the safety assessment of water resources in karst region.

**Keywords**
Karst area; DPSIRM conceptual framework; Grey-set pair model; Water resources; Security.

**Research on the List of Air Pollutants Control techniques for the Whole Process of Printing Enterprises in Typical Area of China**

FANG Gang*, LI Zixiu*, ZHOU Changbo**, GUO Yajing*, DANG Chunge*, HAN Guimei*

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**Abstract**
Volatil organic compounds produced in the printing industry are important sources of industrial atmospheric pollutants. This paper chooses Langfang printing industry as the research object, and adopts the concept of cleaner production, and carries out research on the whole process control technology list of the printing industry. By analyzing domestic and foreign ink-related policies, regulations and control standards, the paper puts forward the indicators and requirements for the selection of printing inks in China; uses field research and on-site test to identify key pollution-producing nodes in the printing industry, and propose corresponding prevention and control technologies; The industry’s mainstream end-of-pipe treatment techniques (activated carbon adsorption, catalytic combustion, photo-oxidation, low-temperature plasma, etc.) carry out cost-effective analysis, and screen out the proposed techniques, and finally put forward a list of air pollutants control techniques of the whole process for printing enterprises, which provides technical support for printing enterprises to reduce atmospheric pollutants.

**Keywords**
Air pollutants; Cleaner Production; techniques list; Whole process control.

**Research on differentiated solid waste treatment technique for water-based drilling in natural gas exploitation**

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**Abstract**
As a low-carbon, clean energy source, natural gas is gradually becoming an important force driving global energy transformation. As the demand for natural gas in the world increases, the mining process produces a large amount of drilling solid waste, which occupies a large amount of land resources. The solid waste generated by drilling in the deep well section (above 3000 meters) will cause oil and hydrocarbon pollution to the soil and groundwater, destroying the ecosystem. In view of these problems, this paper studies the characteristics, pollution characteristics and physicochemical properties of drilling solid wastes, and classifies the solid wastes according to the drilling depth and mud performance, and then adds FeSO₄ to improve the high alkali characteristics and incinerate at 900 °C. Differentiated treatment, achieving the pollution index value of drilling solid waste leachate pH<9 and petroleum hydrocarbon<450mg/kg, meeting the first type of land for China’s Class I general industrial solid waste and Soil Control Risk Control Standard for Soil Environmental Quality Construction Land. The requirements of the six building materials indicators meet the requirements of general roadbed construction in highway subgrade construction specifications; this technology completely solves the environmental pollution problems caused by drilling solid waste, and realizes the solid waste recycling resources.

**Keywords**
Gas drilling solid waste; integrated management; resourceutilization.

**The safety evaluation of water resources based on DPSIRM conceptual framework in karst region**

Fengtai, Zhang*, Lachun Wang*, Weici Su*, Changcheng Sun*
Abstract

Aiming at the problems existing in the safety evaluation of water resources, such as partial evaluation indexes, the omission of single index membership information and subjectivity problem of determining weight. In a typical karst area-Guizhou province as an example, combining with the characteristics of water resources in karst region, based on conceptual framework of driving force-pressure-state-impact-response-management (DPSIRM) to build evaluation index system of water resources security, with the help of grey-set pair model to make quantitative evaluation of Water security of Guizhou in 2005-2005. The results show that: the water security in Guizhou in 2005 and 2006 in the criticality safety state, 2007-2012 in a safe state, water security in Guizhou to present the overall good posture. the state of water resources and water resources management were the important factors affecting the safety of water resources. Continued to adjust the economic structure and transformation of the mode of growth at the same time, improve the utilization efficiency of water resources, increase investment in infrastructure construction of water resources, strengthening the construction of water resources management system and improve the implementation of water resources management system, these were the fundamental guarantee of the water security in Guizhou. The applicability of the evaluation model and index system was stronger, the evaluation results more objective, provided a new perspective and a new method for the safety assessment of water resources in karst region.

Keywords

Karst area; DPSIRM conceptual framework; Grey-set pair model; Water resources; Security.

Exploring complexity and contradiction in outsourcing: insights from a societal metabolism perspective

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Abstract

One of the challenging features of our energy system is that many of our energy choices involve what economists call “externalities.” That is to say, the choices that individuals make about the production or consumption of a particular energy source impose costs on others in the form of welfare, climate, and national security. The globalization of the energy market has increased the complexity of the energy system to the point of turning it into a ‘mega-issue’: energy is, among all policy fields, the one exhibiting more externalities on a global scale and by far the most complex, path dependent, and embedded one. Over the past decades, the EU economy has undergone a significant structural shift from being a prime producer to being a prime consumer of goods, focusing its activity on the service sector - what is also known as a tertiarization of the economy. In terms of energy, the EU tends to import primary energy sources (PES) that are lacking on its territory, and to locally transform them into energy carriers (mainly electricity and fuels), although differences and exceptions among countries exist. Despite efforts to increase its security of supply, the EU remains a net energy importer: in 2016, the EU imported 35% of all the energy it consumed, at a cost of more than €1 billion per day. If embodied imports (also known as ‘virtual imports’) are accounted, the gap between energy consumption and production (one traditional measure of energy security) in the EU is even larger than commonly assumed. In this work, we claim that the bandwidth of the EU sustainability is increasingly being challenged: environmental pressures on land, water and climate as well as human capital requirements variously externalized by EU countries have resulted in a further broadening of energy security and transition to capture various energy-related insecurities. Not to mention the implications that this has in terms of environmental justice: externalization may be understood as market failures, but they may also be seen as (provisional) cost-shifting successes, usually at the expenses of developing countries that are either cut adrift from decision-making or subject to less stringent policies. These side-effects are serious and, if left unchecked, will impose limits on the ultimate extent of globalization’s spread. Addressing this will require novel approaches and may result in some counter-intuitive solutions.

This work represents an example of Quantitative Story-Telling developed in the EU project MAGIC - https://magic-nexus.eu/. Quantitative Story-Telling is an alternative to the concept of “evidence-based policy” where the ultimate goal is to check the robustness of knowledge claims in face of uncertainty.

Keywords

outsourcing, complexity, societal metabolism, Water-Energy-Food nexus.
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