Sustainable development in period of climate crisis

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Abstract

The ongoing process of climate change has shown that sustainable development of humankind is a necessity. Existing resources need to be used in a form of a circular economy, and no more in a linear economy as has been the case until now. Resources need to be better managed to meet the needs of future generations. Therefore, energy, water and environment systems need to be integrated in order to slow down their overexploitation. This paper discusses some of the latest developments in three main areas of sustainability, i.e., energy, water and environment, that emerged from the four "Sustainable Development of Energy, Water and Environment Systems" (SDEWES) Conferences that took place in 2020. The purpose of this review introduction article is to provide a brief introduction to the field and the articles included in this Virtual Special Issue. As such, it acts as an editorial paper for the virtual special issue of the Journal of Environmental Management, dedicated to the SDEWES 2020 conferences.

Keywords: Water and wastewater treatment; Environmental management and assessment; Energy systems

1. Introduction

The IPCC's Sixth Assessment Report on the physical science basis of climate (IPCC, 2021) established human influence on the climate system as a fact, with an estimated increase in global surface temperature of 1.09°C compared to the 1850-1900 period. Methane has been confirmed as the second most important greenhouse gas, after carbon dioxide. The most significant sources are from agriculture, followed by fossil fuel production and usage. It is clear that humanity is dealing with a climate crisis with time running low, necessitating the the decarbonization of most industrial activities in order to slow down the ongoing process of climate change. This includes decarbonization of transport, industry, the power sector and agriculture by the means of social, economic, and technological pillars of sustainable development, and following the principles of circular economy. It is clear even now that the proposed nationally determined contributions under the Paris Agreement will be inadequate to limit the increase in average global temperature below 1.5°C, even if they are fully accomplished. As a result, novel actions are proposed such as the European Green Deal, which aims to reduce the net greenhouse gas emissions by at least 55% by 2030. The urgency of climate actions does not only ask for social consensus on global joint efforts, but also for an interdisciplinary approach with a focus on environmental management.

After four successful years of cooperation between the Journal of Environmental Management (JEMA) and the Sustainable Development of Energy, Water and Environment Systems (SDEWES) conference series that resulted in four JEMA Virtual Special Issues (VSI), in 2016 (Mikulčić et al., 2017), in 2017 (Mikulčić et al., 2019a), in 2018 (Mikulčić et al., 2020), and in 2019 (Mikulčić et al., 2021a) the cooperation between JEMA and the SDEWES conference series has been continued in 2020.

In 2020, four SDEWES conferences have been organized. First, from February 9 till 12, 2020, the 2nd Latin American SDEWES conference edition took place in Buenos Aires, Argentina. The conference brought together 110 scientists, researchers and experts in the field of sustainable development from 26 countries. There were 120 presentations, 2 invited lectures and a panel discussion on the topic of climate change with some of the most distinguished experts in the field. Due to the outbreak of the COVID-19 pandemic, the other three SDEWES conferences were organised virtually. The 1st Asia Pacific SDEWES conference edition was held virtually April 6 till 9, 2020. In total, 97 presentations were available on-demand to the 134 registered participants from 36 countries, and generated over 1300 comments in a lively discussion. The 4th South East Europe SDEWES conference was virtually held June 28 to July

2, 2020. It brought together 190 scientists, researchers and experts in the field of sustainable development from 37 countries. There were 130 presentations and 4 invited lectures during this conference. The last of the four conferences, the 15th SDEWES conference was virtually held from September 1 till 5, 2020. It brought together around 300 scientists, researchers, and experts in the field of sustainable development from 55 countries. The registered participants were able to listen to over 300 presentations, four invited lectures and a Panel on Climate Neutrality in Cities. From all the archival submissions, 45 were invited to contribute to this VSI. After a rigorous JEMA review process, 22 papers were accepted for publication, and form this VSI. These 22 papers can be classified into three main research fields: water and wastewater treatment (6 papers); environmental management and assessment (11 papers) and energy systems (5 papers). This paper shortly evaluates the named three groups of papers, and gives the JEMA readers a sense of continuity, by reviewing some previous publications in the same research area.

2. Background

Water, as a vital resource for human life and its wellbeing, has over the year been the research topic of several studies published in different journal's Special Issues dedicated to SDEWES conference series. Water demand has grown continuously in most parts of the world in recent times. The sustainability of water systems must be ensured to conserve the social and economic benefit of access to qualitative water resources (Almazán-Gómez et al., 2021). The impacts of water efficient technologies on energy intensive water systems in remote and isolated communities was investigated by Beal et al., (2016). The increasing pressure on freshwater resources motivates the need for exploring new water harvesting methods. Atmospheric water generation, or air to water, as a potential under-explored component of the water solutions portfolio, was analysed by Moghimi et al. (2021). Fresh water supply and storage systems have been studied all over the world: China (Kong et al., 2021), Italy (Maiolo et al., 2021), Brazil (Okumura et al., 2021), Australia (Talent, 2019), Ghana (Kumasi, 2018), United Arab Emirates (Khan et al., 2019) and Morocco (Ersoy et al., 2021). Topics related to water resource management, groundwater remediation and preservation of existing groundwater wells have also been extensively studied. The Total Site Centralised Water Integration method for water reuse was studied by Ahmad Fadzil et al., (2020). Vocciante et al. (2018) investigated using the Water Footprint methodology. Wang et al. (2018) studied groundwater remediation by adsorption of ammonium. The same study approach was used in

the subsequent study by Jia et al. (2019). The water-energy nexus was the research topic of several studies. Suarez and Urtubial (2016) investigated the performance of a direct contact membrane distillation system driven by salt-gradient solar ponds. Burić et al. (2021) analysed potential locations for energy harvesting using high-resolution hydrodynamic models.

Wastewater treatment has also been the topic of several studies. Kumar and Kumar (2020) investigated wastewater stabilization ponds. Crude oil production site water treatment was investigated by Ngene and Tota-Maharaj (2020). Pre-treatment of acetic acid from food processing wastewater was studied by Suwannahong et al. (2021). Iron and steel production processing wastewater treatment was analysed by Pitás et al. (2020). Carbon Footprint analyses of microbial electrolysis cells in wastewater treatment plants were done by Gil-Carrera (2020). Modelling tools for the decarbonization of wastewater treatment plants were presented by Nakkasunchi et al. (2021). The work by Kamizela et al. (2021) analysed the technological unconventional system of a small wastewater treatment plant with some modifications generating ecological profits, mainly related to fertilizer, biomass or peat substitution. Deng et al. (2015) analysed the drying process of long cylindrical oily sludge. Technical solutions for sewage sludge and petrochemical sludge co-firing were studied by Deng et al. (2020). Sewage sludge incineration was investigated by Zhuang et al. (2020).

The *environmental management and assessment* research topic has been studied significantly. Different technologies and applications have throughout the years been environmentally assessed: a sustainability assessment for the chemical industry was done by de Faria et al. (2021); sugar-ethanol production was the subject of study done by Lozano-Moreno and Maréchal (2019); life cycle assessment of a small-scale methanol production system was analysed by Eggemann et al. (2020); offshore processing of carbonated natural gas together with CO_2 capture and store technology was studied by Teixeira et al. (2019) and by Gonzaga et al. (2020), and in a subsequent study by Wiesberg at al. (2021a); life cycle assessment of cleaner production measures in monosodium glutamate production was investigated by Yang et al. (2020); impact of electric vehicles was investigated by Ajanović and Haas (2019); the redesign of the mouthwash production chain based on environmental performance indicators was studied by de Moraes et al. (2021).

The waste management systems were also the topic of several studies. Klemeš et al. (2020) analysed the minimization of the present and future plastic waste use related to COVID-19. Catalytic decomposition of mixed plastic waste was studied by Kremer et al. (2021a). Tenev et al. (2019) investigated cotton industry waste materials. An analysis of green technology investments for Chinese waste electrical and electronic equipment processing was presented by

Li and Wang (2021). Anić-Vučinić et al. (2020) investigated the metal content in waste printed circuit boards and their electronic components. Air pollution in Chin was the subject of the work done by Jia (2021).

Several studies performed a techno-economic or socio-economic feasibility analysis of different technologies and applications. A biomass-based district heating system techno-economic, social and environmental assessment analysis was done by Bozhikaliev et al. (2019). An economic feasibility analysis and optimization of hybrid renewable energy systems for rural electrification in Peru was studied by Rinaldi et al. (2021). The techno-economic assessment of a biorefinery process was performed by Tschulkow et al. (2020), and in a subsequent study by Meramo-Hurtado et al. (2021). A techno-economic assessment of bioenergy production from sugarcane bagasse with carbon capture and storage was performed by Wiesberg et al. (2021b). A thermo-economic analysis of a Rankine cycle used for waste-heat recovery in biogas cogeneration plants was studied by Holik et al. (2021). The techno-economic performance of photovoltaic installations in urban areas was done by Fuster-Palop et al. (2021). Micari et al. (2020) performed a techno-economic analysis of an integrated proces for the treatment of coal mine effluents. Manfren et al. (2021) developed a techno-economic analysis for smart energy services and technologies in buildings. An economic and environmental analysis of increasing renewable energy penetration and energy independence of island communities was performed by Barone et al. (2021). The economic performance of pyrolysis process of mixed plastic waste was investigated by Larrain et al. (2020).

Computational Fluid Dynamics modelling approach has over the years been extensively used to analyse different physical and chemical processes and their environmental impact. These studies include: radiative heat transfer impact on a temperature distribution inside a real industrial swirled furnace (Jurić et al., 2020); flow and heat transfer performance for a water-cooling grate in a biomass boiler (Yang and Mikulčić 2021); effusion cooling of a gas turbine combustor liner (Wang et al., 2021a); thermal performance and pressure drop in a plate heat exchanger (Zheng et al., 2021); particle separation technologies (Mikulčić et al., 2014); sewage sludge combustion (Žnidarčič et al., 2021); biomass pyrolysis process (Zhang et al., 2021); nitrogen oxides emissions from solid fuel combustion (Bešenić et al., 2018); nitrogen oxides formation reduction in a low volatile coal-fired boiler (Liu et al., 2018); and nitric oxide emission from an internal combustion engine (Jurić et al., 2021).

Energy systems and the energy transition research topics have been investigated significantly (Urbaniec et al., 2016). Following are some of the papers that examined the energy transition research topic: prosumers on the electricity market were the topic of study by

Perković et al. (2017); the performance assessment of a renewable micro-scale trigeneration system based on a biomass steam cycle, a wind turbine and a photovoltaic field was investigated by Figaj (2021); the integration of hydrogen technologies in island energy systems was analysed by Nastasi et al. (2021); coupling of the heating and power sectors was studied by Jimenez-Navarro et al. (2020); integration of photovoltaic electricity with shallow geothermal systems for residential microgrids was investigated by Peković et al. (2021); hybrid solar heating and cooling system for a residential use was studied by Figaj and Żołądek (2021); combustion of waste gas in a low-swirl burner under syngas and oxygen enrichment was analysed by Skvorčinskienė et al. (2021); the performance of a compression-ignition engine for agricultural purposes was investigated by Bietresato et al. (2021); the power generation from floating photovoltaic plants was studied by Tina et al. (2021).

Inherent intermittency of renewable energy sources poses challenges for their further integration in the energy system. Energy storage offers a solution to save energy during peak production for later periods of increased demand when production is lower (Mikulčić et al., 2021b). Therefore, energy storage technologies have also been the research topic of several studies. Some of these technologies include: the use of a post-mining underground infrastructure for compressed carbon dioxide energy storage systems (Bartela et al., 2021); a novel concept of the energy storage system using compressed carbon dioxide, methanation and hydrogen generator (Skorek-Osikowska et al., 2021); phase change materials for energy storage (Wang et al., 2021b); packed bed latent heat storage filled with non-spherical phase changing materials (Grabo et al., 2021); solar energy storage (Durán-Olivencia et al., 2021); thermochemical battery storages (Padula et al., 2021); and thermochemical energy storage (Di Laura et al., 2021).

Application of novel thermochemical methods for the. conversion of biomass and plastic materials has been extensively studied (Mikulčić and Zhang, 2021c). Brigagão et al. (2019) performed a techno-economic analysis of thermochemical pathways for corncob-to-energy. Dynamic modelling of the biomass gasification process in a fixed bed reactor was studied by Cerinski et al. (2020). Sobek and Werle (2021) used a fixed-bed reactor for solar pyrolysis of three waste biomass types. Mlonka-Mędrala et al. (2021) studied the pyrolysis of agricultural waste biomass in order to analyse the production of gaseous fuels and high-quality char. Thermal analysis of apricot kernel shells was investigated by Manić et al. (2020). Ahmad et al. (2021) performed a thermo-kinetic study to elucidate the bioenergy potential of maple leaf waste. Synergistic effects of biomass and polyurethane co-pyrolysis were studied by Wang et al. (2019). Co-pyrolysis and synergistic effect analysis of biomass sawdust and polystyrene

mixtures for the production of high-quality bio-oils was done by Stančin et al. (2021a), and in a subsequent study by Stančin et al. (2021b). Polyurethane plastic waste under different atmospheric conditions was investigated by Mikulčić et al. (2019b).

Hydrogen has received large attention recently as an energy storage option. Hydrogen, as an energy vector, allows energy to be carried and converted to a suitable form when required. There are various ways to store hydrogen. Compressing hydrogen requires more energy because of the lower relative density. Another way to store hydrogen is by liquefying it at −253 °C. However, this process is also energy intensive and up to 40% of the energy is lost in this process (Bhandari and Shah, 2021). Another way how to store hydrogen is in the form of ammonia (Chisalita et al., 2020). Later hydrogen can be recovered from green ammonia (Cha et al., 2021), or ammonia can be directly used as alternative fuel in gas turbines and internal combustion engines (Mikulčić et al., 2021d).

The previously mentioned studies are just some of the papers related to the SDEWES Conference series that have contributed to the knowledge increase in the research area of energy, water, and environmentally sustainable development.

3. This Virtual Special Issue papers

The *water and wastewater treatment* theme consists of six papers in this VSI. The regional development to water ecosystems using ecosystem services as endpoints has been studied by Lu et al. (2021). The most noteworthy threats to the water ecosystem were analysed for the Beijing-Tianjin-Hebei District. The comprehensive household water use profiling and habits/behaviour patterns in water consumption have been investigated by Rahim et al. (2021). The study showed that changes in water consumption behaviour can be easily monitored and that water use profiling enables water conservation through personalised recommendations. The application of digital water metering on water savings within water network levels has been analysed by Monks et al. (2021). The study results showed that the proposed method could both improve customer satisfaction scores and lower the water use. Mortula et al. (2021) investigated the leachability of microplastics from different plastic materials to water bodies. The study showed that the microplastic particles can disintegrate from the original plastic materials under specific conditions and that special management of plastic waste materials is needed. Rosińska (2021) studied the influence of UV irradiation on PAHs in wastewater. The study showed that the optimal time of UV irradiation was 30 min. After UV irradiation, the total concentration of PAH decreased by 66%, and after the UV/chlorination by 78%. Bipolar membrane reverse

electrodialysis for the sustainable recovery of energy from pH gradients in industrial wastewater has been analysed by Culcasi et al., (2021). The study showed that wastewater systems can be a source of renewable energy.

There are eleven papers in this VSI that are part of the *Environmental management and assessment* theme. Fan et al. (2021) studied the urban and industrial symbiosis for circular economy using the Total EcoSite Integration method. The study showed that the proposed approach minimizes the requirements of energy-intensive thermal drying for waste, subsequently offering a solution with lower environmental footprint and cost. Rosecký et al. (2021) analysed the municipal waste management policy for different territorial levels. The study showed that there is not one single effective public policy dealing with circular economy strategy that fits all territorial levels. Kwarciak-Kozlowska and Fijalkowski (2021) studied the treatment efficiency of landfill leachate during the application of integrated processes of advanced oxidation and biochar adsorption. The study demonstrated that the applied method results in a reduction of pollutants in landfill leachate. Petrovič et al. (2021) investigated the nutrient recovery from digestate obtained by rumen fluid enhanced anaerobic co-digestion of sewage sludge and cattail. The study showed that the precipitate mixed with powdered zeolite shows good potential as a fertilizer. Simultaneous removal of chromate and phosphate using different operational combinations for their adsorption on dolomite and banana peel has been studied by Piol et al. (2021). The study results for a fixed bed reactor filled with a mix of adsorbents, showed removal rates of 99% for phosphate and 70% for chromate. Red mud with other waste materials as artificial soil substitute and its effect on Sinapis alba was analysed by Berta et al. (2021). The study showed that red mud with waste sludge is a promising soil substitute medium for reclamation. The work by Saralegui et al. (2021) focused on obtaining macrophytes growth parameters in order to calculate the most proper greenhouse containers dimensions and their required cultivation periods to be employed in a fixed-bed reactor with a certain effluent flow to filter. The study showed that macrophytes represent a low-cost alternative for the most efficient commercial adsorbents. Dahl et al. (2021) investigated the effect of turbulence, dispersion and stratification on Escherichia coli disinfection in a subtropical maturation pond. The study showed that model results can assist in management strategies for maturation ponds such as off-take locations/times and evaluating seasonal variations in sunlight disinfection. Rong et al. (2021) performed a quantitative analysis of economic and environmental benefits for land fallowing policy in the Beijing-Tianjin-Hebei region. The study showed that the established framework could support decision-making in regions facing agri-environmental problems. The work by Pietrapertosa et al. (2021) focused

on the multi-level climate governance arrangements in Italy to investigate how Italian regions/provinces/cities are contributing to achieving national climate commitments. The study results showed that cities are more active than provinces and regions in defining mitigation policies. The analysis of climate mitigation plans of 51 regions and 73 cities in Mediterranean Europe has been performed by Salvia et al. (2021). The study showed that mitigation planning is affected by national regulations and transnational networks and, therefore, cross-border cooperation between Mediterranean regions and cities is needed.

In the *Energy systems* theme, there are five papers. The papers within this theme are investigating the integration of different energy systems, the use of different alternative fuels and pollutant emission problems. Wang et al. (2021c) used the pinch analysis method to investigate a hybrid heating and power system. The study showed that by applying the proposed method, less energy is consumed and that the combined heat and power system production can become more environmentally friendly. Geothermal energy implementation for heating and cooling was assessed by Wang et al. (2021d). The study showed that geothermal energy is a promising renewable energy source that can be utilized to meet various energy demands. A novel reductive catalytic fractionation biorefinery process for transforming wood into high-value end-products has been studied by Tschulkow et al. (2021). The study showed that reductive catalytic fractionation has the potential to stimulate investments from different investors, upstream and midstream, within the wood value chain. A kinetic evaluation and optimization study on NO_x reduction by reburning under pressurized oxy-combustion was performed by ur Rahman et al. (2021). The study showed that the de-NOx process efficiency in an oxygen environment is significantly increases at higher pressure. Catalytic pyrolysis of mechanically non-recyclable waste plastics mixtures was studied by Kremer et al. (2021b). The study showed that all pyrolysis products had a high higher heating value, ranging from 39 MJ/kg to 43 MJ/kg, and showing good potential for further energy use.

4. Conclusions

This VSI editorial addresses a selection of research studies from the four SDEWES conferences in 2020. The studies included in this JEMA VSI were classified into three topics named as: Water and wastewater treatment; Environmental management and assessment; and Energy systems. Some of the solutions for the problems reviewed in this article represent a knowledge gain and a further increase in public awareness on the need for sustainable and responsible

economic development, in the period of climate crisis. The Guest Editors believe that the papers selected for this VSI will be of interest to Journal of Environmental Management readers.

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