

# **Environmental problems arising from the sustainable development of energy, water and environment system**

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## **Abstract**

Integration of energy, water and environment systems is essential in the multidisciplinary concept of sustainable development, as they represent the basic life needs of mankind. Therefore, problems arising from the sustainable development concept need to be carefully addressed to preserve the energy, water and environment resources for future generations. This article discusses some of the latest developments in three main areas of sustainability themes, namely energy, water and environment, that emerged from three Sustainable Development of Energy, Water and Environment Systems (SDEWES) conferences held in 2018. As such, it acts as an editorial paper for the virtual special issue of the Journal of Environmental Management, dedicated to the SDEWES2018 conferences.

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

## **1. Introduction**

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

In 2018, three SDEWES Conferences have been organized. First, from January 28<sup>th</sup> till 31<sup>st</sup> 2018, the first Latin American SDEWES conference edition was held in Rio de Janeiro, Brazil. The conference brought together 180 scientists, researchers and experts in the field of sustainable development from 35 countries and 5 continents. There were 178 presentations in 28 regular and 5 special sessions. Secondly, the 3rd South East Europe SDEWES conference was held June 30 to July 4, 2018 in Novi Sad, Serbia. It brought together 190 scientists, researchers, and experts in the field of sustainable development from around 30 countries. There were 140 presentations, and 30 poster presentations, during this conference. Thirdly the 13<sup>th</sup> SDEWES conference was held on the Italian island Sicily, in Palermo from September 30 to October 4 2018. It brought together 400 scientists, researchers, and experts in the field of sustainable development from around 50 countries. There were 330 presentations, and 80 poster presentations, during this conference. The papers in this VSI are based on archival articles presented at the these three SDEWES 2018 Conferences. From all the archival submissions, 43 were invited to contribute to this VSI. After a rigorous JEMA review process, 25 papers were accepted for publication, and form this VSI. These 25 papers can be classified into three main research fields: Water and wastewater treatment (6 papers); Environmental management and assessment (12 papers) and Energy systems (7 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 and wastewater treatment* studies have over the year been investigated by several papers published in other journal's Special Issues dedicated to SDEWES conference series. Water storage, supply and distribution networks have been studied extensively for different cities, regions, states, and countries all over the world: Cambodia (Czarny et al., 2017), United Arab Emirates (Khan et al., 2019), Australia (Talent, 2019), United States

(Sutherland and Smith, 2018), Lebanon (Bou-Fakhreddine et al., 2018), Ghana (Kumasi, 2018). Water resource management and water scarcity was the topic of the study by Sahin et al. (2018), and a study by Alam et al. (2018). Whereas the minimization of freshwater requirement and wastewater generation was investigated by Mabitla and Majozi (2018). Vocciante et al. (2018) studied groundwater remediation by adsorption of ammonium.

Current and future development trends in Water Footprint methodology have been presented in the study by Wang et al. (2018), and in the subsequent study by Jia et al. (2019a). The supply of water to coastal industrial parks from seawater desalination plants was studied by Jia et al. (2019b). The use of marine sediments from Port of Koper, Slovenia in brick industry was studied by Baksa et al. (2018). Water resource management and wastewater treatment in industry has been investigated in several papers. Inter-plant chilled and cooling water network integration was studied by Leong et al. (2016). The water network integration between two plants was investigated by Ibrić et al. (2017). Galli et al. (2018) investigated the freshwater and saltwater desorption process in chemical plants. Xiong et al. (2017) using fluorine plastic heat exchangers, analysed the water and latent heat recovery from flue gases of a coal fired utility boiler. Haslik et al. (2017) investigated the pollution level of the wastewater coming from a nuclear power plant. Treatment of swine wastewater was analysed by Pena et al. (2017). A waste stabilisation pond-based wastewater treatment plant and the fate of selected contaminants have been studied by Kumar and Kumar (2019). Yukseler et al. (2017) studied the treatment and cleaning of wastewater from textile industry.

Quantitative environmental performance of novel technologies for wastewater treatment plants, and their cleaner and more efficient processes were analysed by several groups. Bavasso et al. (2016) to remove organic carbon and ammonium nitrogen from wastewater analysed the performance of an H-type microbial fuel cell. Mustapha et al. (2017) performed an overall quantitative environmental performance measurement for wastewater treatment plants. Dvoretzky et al. (2018) developed a mathematical model of the microalgae cultivation process in wastewater treatment plants. The possibility of utilizing waste heat from a wastewater treatment facility was investigated by Somogyi et al. (2018). Keppert et al. (2018) presented a novel approach for sorption of different ions on a ceramic sorbent that represents waste from red-clay bricks production.

*Environmental management and assessment* of various sectors, technologies and different applications has been the research topic of several papers. The problem of industrial ecology and the minimization of the environmental burden of Philippine industrial parks was analysed by Promentilla et al. (2016). Biomass logistics and environmental impact of the

sugar-ethanol production was studied by Lozano-Moreno and Maréchal (2019). The pre-treatment of microalgal biomass for enhanced biogas production was assessed by Marques et al. (2018). Environmental assessment for the offshore processing of natural gas with high CO<sub>2</sub> content was performed by Gonzaga et al. (2020). The overall environmental impact of electric vehicles in different regions was investigated by Ajanović and Haas (2019). The environmental performance of a solid waste monetization process applied to a coal-fired power plant with semi-dry flue gas desulfurization was assessed by de Andrade Cruz et al. (2019). The environmental feasibility of integrated sanitation systems was studied by Agunyo et al. (2019).

Economic assessment of different technologies and applications is crucial for a good decision making. Techno-economic assessment of integrated hydrothermal liquefaction and combined heat and power production from lignocellulose residues was studied by Magdeldin et al. (2018). Technical and economic assessment of a 450W photovoltaic system with lithium iron phosphate battery storage was analysed by Carriço et al. (2018). The techno-economic, social and environmental assessment of a biomass based district heating system was performed by Bozhikaliev et al. (2019). The techno-economic evaluation of waste heat recovery by organic Rankine cycle in a crude oil refinery was investigated by Varga and Csaba (2018). The environmental-economic assessment of thermochemical polygeneration from microalgal biomass was studied by Graciano et al. (2018).

Lifecycle assessment (LCA) approach, which takes into account all of the input and output flows needed for a very detail environmental assessment, has been applied in several studies as: utilization of bamboo material (Chang et al., 2018); optimized energy use and water provision in school buildings (Gamarra et al., 2018); tyre manufacturing process (Shanbag and Manjare, 2020); solar energy system based on reused components (Kim et al., 2019); conventional vehicles with different fuel options (de Souza et al., 2018); wastewater and sludge management (Heimersson et al., 2019).

Computational Fluid Dynamics (CFD) modelling as a tool for analysing the environmental impact of various processes, has over the year gained a lot of attention. Therefore, different physical and chemical processes and their environmental impact were studied, as for example: the mist film cooling effect with the deposition process (Wang et al., 2017a); the heat transfer from an electric motor (Grabowski et al., 2016); the heat transfer from an open heat exchanger used in jaggery production modules (La Madrid et al., 2016); the effects of gravity and variable thermal properties on nanofluid convective heat transfer (Li et al., 2018); the ultra-lean gaseous fuel injection during the iron ore sintering process (Cheng

et al., 2017); the reduction of NO<sub>x</sub> emissions from the transport sector by using the selective non-catalytic NO<sub>x</sub> reduction process by Baleta et al. (2015) and Baleta et al. (2017), respectively; the natural gas engine was studied by Wang et al. (2017b); the turbocharged diesel engine was analysed by Petranović et al. (2018); the design improvement and optimization of a natural gas-fired thermoelectric generator was analysed Bargiel et al. (2017).

Air and soil pollution were investigated in several studies. Koval et al. (2018) investigated dust particles in an urban environment, to ensure that industry and community coexist in a mutually beneficial and sustainable manner. Particle separation using cyclone technology was studied by Mikulčić et al. (2014). Cao et al. (2017) studied the particles and trace elements removal from coal-fired power plant flue gases. The absorption of carbon dioxide from flue gases in coal thermal power plants was analyzed by Singhal and Manjare (2018). Fijalkowski et al. (2018) analysed the phytoremediation of a degraded soil from a terrain of a steel mill by using the sewage sludge. Grobelak et al. (2018) studied the alternative fertilization and bacteria soil biopreparation as an alternative soil bioremediation option.

*Energy systems* is the research topic that has been analysed by the highest number of papers published within different SDEWES Special Issues. The complexity of the energy transition, the move from fossil fuel based to renewable energy source (RES) based energy system (Urbaniec et al. 2017) has been studied in several papers investigating different topics. Examples are the energy transition for different countries such as Mexico (Vidal-Amaro and Sheinbaum-Pardo, 2018), Kenya (Karanja 2019), Brazil (dos Anjos et al., 2019), Philippines (Ocon et al., 2019), Germany (Schlör et al., 2018), and Korea (Chung et al., 2018); the role of energy from waste in circular economy (Tomić and Schneider, 2018); the renewable and non-renewable electricity generation (Walmsley et al., 2018); the impact of using rice hull waste for electricity generation (Yu et al., 2016); the nearly zero energy greenhouse concept (Yildirim and Bilir, 2017); the integration of transport and energy sectors in island communities (Dorotić et al., 2019); the possibility for production facilities to act directly on a day-ahead market as independent market players (Perković et al., 2017); the minimization of factory operating and investment costs for a factory acting as a prosumer on the electricity market (Perković et al., 2018); the integration of carbon capture and utilization technologies and variable power production in high renewable energy source based energy systems (Mikulčić et al, 2019b); the use of renewable sources for island energy and desalinated water supply (Calise et al., 2017); the future of the transport sector in sustainable energy systems

(Dominković et al., 2018); the impacts of severe drought on future renewable energy source based energy systems (Jääskeläinen et al., 2018); and the potential for CO<sub>2</sub> emission reduction and energy efficiency increase for campsites in a protected area (Del Moretto et al., 2018).

The exploitation of variable RES (VRES), especially in the energy systems where there is a higher penetration of VRES, acquires special attention (Taseska-Gjorgievska et al., 2019). To fully integrate the VRES, different demand response and energy storage technologies are required (Tronchin et al., 2018). Some of these technologies include electrical battery storages (Roselli et al., 2017), lead-flow-batteries (Lanfranconi and Lilienhof, 2019), compressed air energy storages (Hämmerle et al., 2017), LNG terminals operating as thermal energy storage (Pospíšil et al., 2019), etc.

Biomass and its utilization technologies have been extensively studied worldwide. Biomass gasification efficiency through process control was studied by Mikulandrić et al. (2020). Syngas production by the pyrolysis of perennial grasses was studied by Juchelková et al. (2015). As co-firing of biomass with coal requires only minor modifications to the power plant, it is an attractive immediate and practical way for reducing coal usage and its harmful emissions (San Juan et al., 2018). The co-firing process has been analysed both experimentally and numerically. Deng et al. (2018) studied the oxy-biomass combustion in different atmospheres. Raclavská et al. (2018) investigated the pyrolysis of tetrapak at different temperatures. A waste wood grate-fired boiler was CFD modelled by Rajh et al. (2018). The synergistic effects of biomass and plastic co-pyrolysis were investigated by Jin et al. (2019), and the subsequent study by Wang et al. (2019a). Mikulčić et al. (2019c) studied the polyurethane plastic thermal properties under different atmospheric conditions.

These 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 environment sustainable development.

### **3. This Virtual Special Issue papers**

The *Water and wastewater treatment* theme consists of six papers in this VSI. Petrelli et al. (2019) investigated the use of red mud and pyrolusite for the removal of As and Mn from drinking water. The study showed that water with heavy metal contents below legal limits can be obtained by the combined use of the two adsorbents. The mapping of the value chain processes for the water and wastewater utility companies was done by Chofreh et al. (2019).

The study for the case study for the Khuzestan Urban Water and Sewage company showed that the value chain mapping as part of value chain analysis enables organisations to increase operational efficiency and eliminate waste by 57%. Piol et al. (2019) studied the phosphate desorption process for the recovery and reuse of dolomite and evaluated the possibilities of a final disposal of exhausted dolomite for agricultural soil improvement and application of the desorbed phosphate as fertilizer. The study showed that the obtained extracts could promote the vegetal growth. Kasperczyk et al. (2019) tested the removal of volatile organic compounds (VOCs) and hydrogen sulphide (H<sub>2</sub>S) present in the exhaust air of a wastewater treatment plant by a compact trickle-bed bioreactor. The study showed that at stable bioreactor working conditions, removal efficiencies for H<sub>2</sub>S and VOC were >95%. A new technical solution for sewage sludge processing and management in small and medium-sized municipal wastewater treatment plant was studied by Grobelak et al. (2019). The study showed that obtained sewage sludge can be recycled as biomass for combustion. Bressani-Ribeiro et al. (2019) analyzed the developing sustainable sewage treatment systems and its social acceptance for different scales and regional scenarios in the state of Minas Gerais, Brazil. The study showed that obtained results could serve as support for decision-making on the planning and implementation of new sustainable sanitation solutions.

There are twelve papers in this VSI that are part of the *Environmental management and assessment* theme. Bala et al. (2019) investigated the pretreatment and the consequent anaerobic digestion of the organic fraction of municipal solid waste (OFMSW). Based upon the experimentally obtained results, a kinetic model for the anaerobic digestion of NaOH treated OFMSW and reaction pathway were proposed. Kucbel et al. (2019) investigated the properties of compost from household food waste produced in automatic composters. The study showed that there is an opportunity to reduce the landfill deposition of waste containing biological components by using automatic composters for household food waste. Ko et al. (2019) analyzed the impact of a specific enzyme for fibers, on the surfaces, roughness and height of the fibers. The study results showed that the treatment with cellulase swelled the fibers in the absence of refining, and a better fibrillation on the fibers treated with cellulase after refining. Placek-Lapaj et al. (2019) investigated the potential for carbon sequestration in a brown coal open-cast mine by phytoremediation using scots pine and giant miscanthus plants. In reclamation of post-mining landscapes, the effect of sewage sludge, compost and lake chalk amendments, combined with plants was investigated during field experiments. The study showed that the stabilization of compost by lake chalk application was a good method to improve the efficiency of carbon sequestration in soil and carbon phyto-sequestration. An

environmental economic trade-off analysis on CO<sub>2</sub>-enhanced oil recovery and CO<sub>2</sub> capture and storage was performed by Roefs et al. (2019). The environmental economic trade-off analysis of this study showed that costs increase if CO<sub>2</sub>-enhanced oil recovery is followed by CO<sub>2</sub> capture and storage, but the net present value remains positive and the global warming potential is reduced. Teixeira et al. (2019) performed thermodynamic simulations and economic-environmental assessments on implementing supersonic separators in offshore natural gas processing aiming at anti-hydrate recovery and CO<sub>2</sub> dehydration for enhanced oil recovery. The study showed that the proposed system creates economic leverage sustaining carbon capture and storage without loss of competitiveness. Švédová et al. (2019) investigated the water-soluble ions in dust particles in the City of Ostrava. The study showed that the highest concentrations of all water-soluble ions were encountered in particles below 0.952 μm, which is generally related to combustion processes. In a subsequent study, Strbova et al. (2019) investigated the particulate matter air pollution for the town of Napajedla, Czech Republic. The study showed that multivariate statistical analysis using organic compounds allows proper distinguishing of main air pollution sources between sampling locations even for a small urban area. Sahin et al. (2019) using the integrated approach that combines the Bayesian Network with GIS, studied the sea level rise induced coastal erosion and assessing the implications of adaptation measures. The outcomes of this work support risk-based adaptation planning and can be used for land use planning decisions. Sebestyén et al. (2019) developed a network-based model to study interlinked ecological, economic, environmental and social problems. The study showed that data-driven networks are applicable to strategic environmental assessment. Kuang et al. (2019) investigated the effectiveness of a developed “Soft Traffic Management (STM)” concept. The developed concept proactively analyzes the traffic impact of transport planning strategy before implementation. The study showed that the extended busway can significantly relieve traffic congestion in the investigated city in Australia. Life cycle assessment of olive oil production in southern Italy was investigated by Guarino et al. (2019). The study showed that the agricultural stages cause more than 70% of the life cycle environmental impacts, whereas bottling is a critical step in terms of environmental impacts among the transformation stages.

In the *Energy systems* theme, there are seven papers. The economic impacts of an energy transition, from classical fossil fuelled to renewable sources for the pig sector in Spain has been investigated by Valiño et al. (2019). The study showed that the energy transition is possible and that even a slight increase in pig production and exports can be achieved. Cruz et al. (2019) analyzed the CuO-CeO<sub>2</sub> redox properties and catalytic performance towards CO-

PROX reaction for fuel cell applications. The study showed that redox stability depends on the CuO/CeO<sub>2</sub> catalysts synthesis method and that the method has an impact on the preferential oxidation of CO. Ancona et al. (2019) using the fluidized-bed gasification process investigated the quality of biomass from an experimental site in which a plant-assisted bioremediation technology has been applied to reduce the soil heavy metal and polychlorinated biphenyl contents. The study results showed that a specific treatment for pollutant capture is necessary only when the roots, the part of the plants where these contaminants are concentrated, are sampled and used for the gasification process. Růžičková et al. (2019) studied the organic compounds in char and soot from the combustion of biomass in boilers. The study showed that char and soot in deposition from combustion of biomass can be distinguished chemically, and that char and soot differ in the content of elemental carbon and organic carbon. Stančín et al. (2019) experimentally analyzed the waste polyurethane from household appliances to investigate its utilization possibilities. The study showed that due to high chlorine content the analyzed waste polyurethane cannot be used for waste-to-energy applications. The biomass and polyurethane waste co-pyrolysis and its synergistic effect on soot formation at high temperatures have been studied by Wang et al. (2019b). The study showed that the synergistic effect decreased soot yield and its particle size while increased soot oxidation reactivity. Mo et al. (2019) proposed a facile one-step microwave-assisted method for kaolinite intercalation and grafting. The study results showed that the effectiveness of the proposed kaolinite modification method may be useful for Pickering emulsion stabilization in oil recovery applications.

#### **4. Conclusions**

This VSI introduction paper addresses a selection of research works, from recent Sustainable Development of Energy, Water and Environment Systems conferences, on three topics named as: Water and wastewater treatment; Environmental management and assessment; and Energy systems. The researchers from around the world studied the environmental problems arising from the sustainable development within these three themes. Some of the solutions for the problems reviewed in this article, represent a knowledge gain, and further increase in public awareness on the need for an environmentally responsible economic development. 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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