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Editorial

Biomass Energy for Environmental Sustainability

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Global population growth and rising living standards have significantly impacted global energy consumption. Using fossil fuels contributes to severe environmental pollution due to the emission of large volumes of greenhouse gases [1]. Many researchers are actively developing renewable energy from alternative sources to address these concerns. Biomass energy can provide cleaner combustion and reduces greenhouse gas emissions to the atmosphere compared with fossil fuels, leading to environmental sustainability. However, significant challenges must be addressed for this energy resource to compete with fossil fuels, including improving the quality of products, ensuring economic feasibility, etc. Thus, this editorial presents the recent advances in the synthesis, processing, technology, and applications of bioenergy and biofuel resources toward environmental sustainability and economic viability.

The biochemical approach is one of the advanced technologies for converting biomass into biofuel. Anaerobic digestion (AD) is a promising and established technology for converting biomass to biogas, which can be used to generate electricity. The AD of biomass wastes poses several challenges, including low biogas yields, poor buffering capacity, low-quality end products, and potential variability. Two possible explanations for these deficiencies are low mass transfer or a recalcitrant feature of biomass wastes. Some techniques have been proposed to overcome these issues, improving the anaerobic process's efficiency. Khan and Ahring proposed wet explosion pretreatment to degrade wheat straw lignin [2]. The molecular weight of lignin can be reduced, while the degree of methoxylation of the lignin fraction in biomass can be increased through wet explosion pretreatment, facilitating anaerobic digestion. The authors observed that the lignin pretreated via wet explosion resulted in the highest lignin degradation and methane production compared with the untreated lignin. Borek et al. presented a new approach for the leaching of organic liquid followed by methane fermentation [3]. A prototype installation was designed to enhance the efficiency of the process by flushing manure with distilled water. Flushing the manure improved production efficiency, and a significant amount of biogas was produced after 4 days. However, raw biogas usually contains impurities, including water vapor, CO_2, and H_2S. Nguela et al. developed a biogas purification system to enhance the biogas quality [4]. The solutions in this system rely on purification methods comprising water absorption processes and iron oxide, activated charcoal, and steel wool adsorption. Applying the purification system could significantly enhance biogas production by up to 95%.

Physiochemical conversion is another technique to convert biomass into solid fuel. Kantová et al. investigated the energy potential of pellets derived from spruce sawdust, spruce bark, and pine cones in different ratios [5]. They demonstrated that adding pine cones and spruce bark to spruce sawdust changes the nitrogen content, ash content, and melting temperature. The energy requirement for the grinding process was analyzed, and it was found that drying temperature, grinding system, and biomass types are the significant

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factors influencing grindability. In addition, forage grain centrifugal-rotary grinders have emerged as promising equipment for grinding grain materials. Romaniuk et al. employed the theory of physical similarity and dimension in investigating a centrifugal-rotary chopper of forage grains [6]. This method allows researchers to scale the experimental data and acquire an improved centrifugal-rotary shredder while ensuring product quality. It also outlines the energy costs of the grinding process and helps to determine the ratio of shredder parameters that will result in lower energy consumption. Moreover, biodiesel has gained recognition as a viable alternative to fossil fuels, as it is a renewable and environmentally friendly energy source. Heterogeneous catalysts have raised interest among researchers because they eliminate many problems associated with homogeneous catalysts, such as elongated separation, purification stages, and waste generation [7]. The advantages of calcium oxide catalysts over other heterogeneous catalysts include their affordable price, low solubility in methanol, low toxicity, and high availability in nature.

Cultivating perennial wild plant mixes (WPMs) is gaining more critical attention in achieving sustainability with bioenergy generation. WPMs are prospective perennial cultivation systems for biogas generation [8]. In comparison with conventional biogas crops, WPMs contribute to an increase in agrobiodiversity by providing a dynamic and various species composition of flowering plants in the form of primarily wild plants. Although WPM cultivation provides significant social–ecological benefits over conventional biogas crop rotation systems, its average methane yield remains significantly less than that of conventional biogas crops. Thus, more land is required to generate the same quantity of bioenergy (as biogas). Despite this, WMPs have several complementary advantages, particularly concerning biomass production's diversity and ecological performance. Moreover, the polluted soil-grown plants (*Elymus elongatus* L. and *Zea mays* L.) might be utilized to improve biomass production for energy purposes. Boros-Lajszner et al. examined the heating value of the plants growing on soil containing Ni^{2+}, Co^{2+}, and Cd^{2+} [9]. Due to its high tolerance to heavy metals, *Elymus elongatus* L. was more effective than *Zea mays* L. in the phytoremediation of the soils contaminated with Cd^{2+}, Co^{2+}, and Ni^{2+}. The biomass of *Elymus elongatus* L. and *Zea mays* L. grown in the soil contaminated with heavy metals had a high heating value ranging from 14.6 to 15.1 MJ per kg of air-dried biomass. In addition, Wyszkowska et al. studied the effects of Ni^{2+}, Co^{2+}, and Cd^{2+} on the biomass yield and calorific value of *Festuca rubra*, and the heavy metal concentrations in soils and plants [10]. As a result of these studies, it has been established that this plant species is capable of growing in soil polluted with Ni^{2+}, Co^{2+}, and Cd^{2+}. *Festuca rubra* had C, O, H, N, S, and ash contents of 46.05%, 34.59%, 5.91%, 3.49%, 0.19%, and 9.76%, respectively. *Festuca rubra* had a calorific value of 15.924–16.790 MJ/kg plant dry mass and a combustion heat value of 17.696–18.576 MJ/kg. Despite heavy metal contamination, *Festuca rubra* has a stable calorific value; therefore, it can be used to produce energy from soils contaminated with heavy metals.

When developing biomass as an alternative energy resource, an extensive assessment of the logistic supply chain of biomass feedstocks is required to make biofuels profitable. The evaluation of the logistics and costs for the production of cellulosic ethanol in Mexico was conducted by Becerra-Pérez et al. [11]. Seven links and three minimum selling prices (MSPs) for agricultural wastes were analyzed using a value chain methodology. In addition, the harvest index (HI), the crop residue index (CRI), nutrient substitution via the extraction of agricultural wastes, and the harvest costs of corn stover were estimated. As a result, feedstock cost significantly influences the economic feasibility of cellulosic ethanol, and it is crucial to have logistical information on agricultural residues and their costs in Mexico.

In conclusion, biomass energy presents an effective solution to the present energy and environmental concerns. The articles collected for this editorial offer insights into advanced conversion and upgrading techniques that could improve the quality of biomass products. Thus, this editorial provides a preliminary step in this emerging field and a guideline for policymakers and investors for the commercialization of biomass energy.

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