Unlocking Integrated Waste Biorefinery Approach by Predicting Calorific Value of Waste Biomass

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Abstract

The shortage of fossil fuel reservoirs with negative environmental impacts such as climate change and global warming has triggered the world's shift to alternative energy sources to meet the growing population's energy demands. Hence, utilizing and converting waste biomass through thermochemical and biochemical technologies has emerged as a reliable option for future energy sources, which will be economically viable and environmentally sustainable. The current study assesses various waste biomass materials' high heating value (HHV). Various biomass waste samples were collected, including date leaves, date branches, coconut leaves, grass, cooked macaroni, salad, fruit and vegetable peels, vegetable scraps, cooked food waste, paper waste, tea waste, and cardboard, and characterized for proximate analysis. The results revealed that all the collected waste biomass was rich in OM content. The total OM for all the waste biomass ranged from 79.39% to 98.17%. Likewise, the results showed that all the selected waste biomass resulted in lower ash content and high fixed carbon content associated with high fuel quality. Based on the proximate analysis, various empirical equations have been tested to predict HHVs, and it was observed that the heterogeneous nature of various types of biomass waste considerably affects the HHVs and hence has different fuel characteristics. Similarly, the HHVs of waste biomass were also determined experimentally using the bomb calorimeter, and it was observed that among all the selected waste biomass, the higher HHVs were recorded for the cooked food waste components, where the highest HHVs (21.19 $MJkg^{-1}$) resulted in cooked food waste followed by cooked macaroni (20.25 $MJkg^{-1}$). The comparison revealed that experimental HHVs for the selected waste biomass were slightly deviated from and predicted HHVs. However, the findings demonstrated that moisture content significantly affects the HHVs where the wet biomass resulted in lower HHVs however drying significantly enhanced the energy content. Based on HHVs, various thermochemical and biochemical technologies were critically overviewed to assess the waste biomass suitability to valuable products such as biogas, liquid fuel, heat, and chemicals. It has been emphasized that based on sustainable nature, valorizing waste to energy technologies provides the dual benefits of sustainable management and the production of cleaner energy to reduce the dependency on fossil fuels. However, the key bottleneck in commercializing the biorefinery concept and waste to energy systems requires proper waste collection, sorting, storage, and continuous feedstock supply. Moreover, to facilitate global recognition, related stakeholders should be involved in designing and executing the waste biomass supply chain at all levels of the hierarchical decision-making process.

Key words: waste biomass, proximate analysis, high heating values, waste to energy, biofuel