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Review of Energy Crop Waste Utilization as an Alternative to Heating Fuel (Firewood)

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Abstract: *The availability of energy is a critical determinant of economic progress for any nation. Given the finite supply, rising costs, and non-renewable nature of fossil fuels, there is an urgent need to explore alternative energy sources. Among the various options, biomass energy has emerged as a promising and sustainable alternative. This study focuses on the production and comparative analysis of solid fuels derived from agricultural waste, specifically groundnut shells and maize cobs, as potential substitutes for traditional heating fuels such as firewood. The research highlights the calorific values of these biomass materials and their suitability for domestic energy applications.*

Keywords: *Biomass energy, Agricultural waste, Calorific value and Domestic energy*

I. Introduction

Agricultural waste encompasses a wide range of by-products generated from farming activities, including manure, crop residues, pesticides, herbicides, and waste from poultry and slaughterhouses. In developing countries like Nigeria, agricultural production has intensified to address food insecurity, resulting in a significant increase in agricultural waste. Annually, Nigeria produces over 18 million tons of agricultural waste, including straws, stalks, husks, cobs, shells, sawdust, and peels, while global production exceeds 998 million tons (Olanrewaju et al., 2021). Despite this, a substantial portion of these wastes remains underutilized, posing environmental challenges related to disposal and management.

Approximately 3 billion people worldwide rely on coal, kerosene, biomass, and wood for domestic cooking, contributing to deforestation and the loss of 3% of global forest cover annually (FAO, 2020). In Nigeria, the scarcity of fuelwood has led to increased dependence on kerosene and gas for cooking, exacerbating deforestation and environmental degradation (Adeleke et al., 2022). The unsustainable use of these fuels, coupled with their anticipated depletion, underscores the need for alternative energy sources. Biomass briquettes, produced through carbonized or uncarbonized densification, offer a viable solution to this challenge (Eze et al., 2023).

Biomass fuels are abundant, cost-effective, and renewable when managed properly. This study reviews the calorific values of briquettes made from maize cobs and groundnut shells, two common agricultural wastes, and evaluates their potential as alternative heating fuels.

II. Types of Biomass

Biomass can be categorized based on its source and composition. The table below provides an overview of biomass types and their examples:

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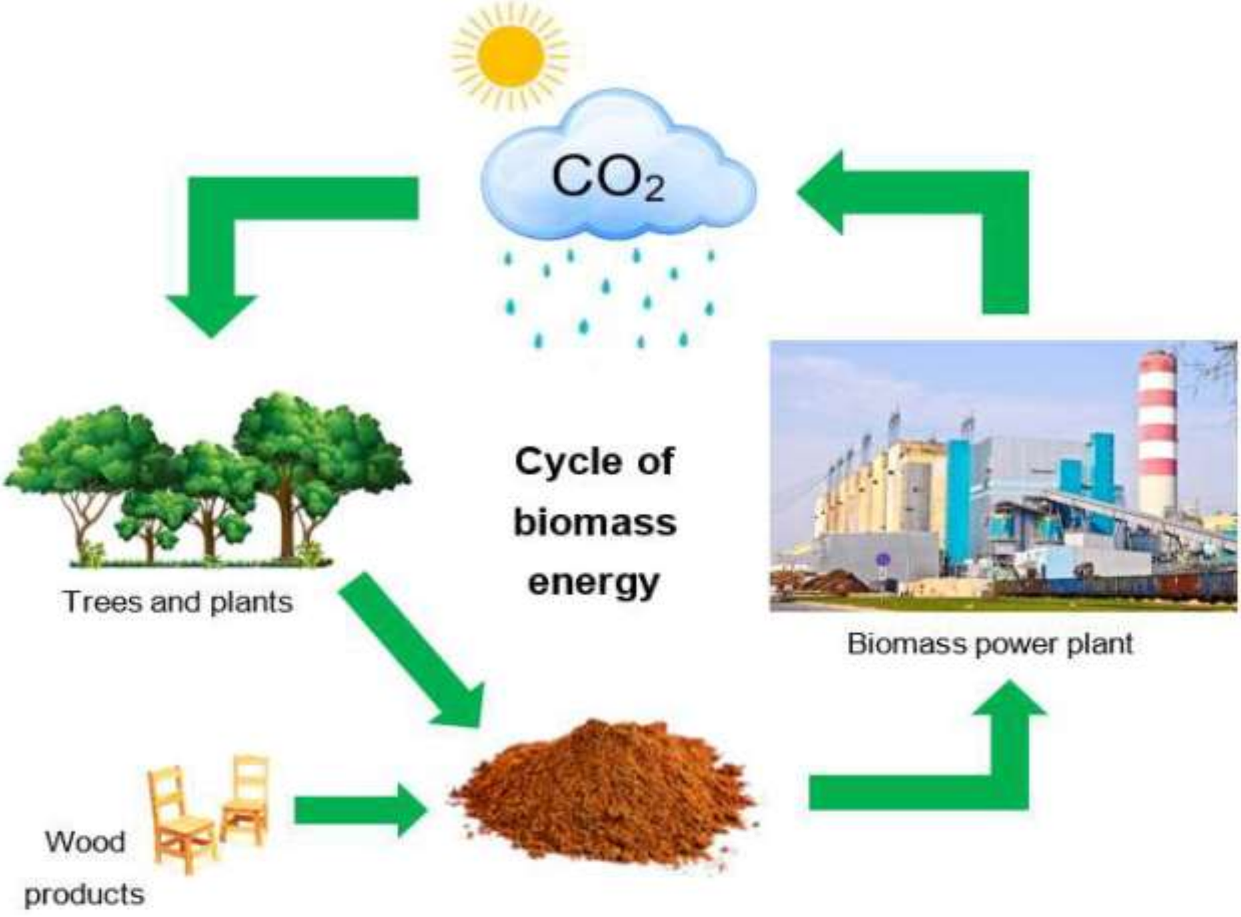
Supply Sector	Type	Examples
Agricultural Residues	Dry lignocellulosic agricultural residues	Straw (maize, cereals, rice), sugar beet leaves, residue flow from bulb sector
Livestock Waste	Solid manure (chicken manure), liquid manure	Cow, pig, and sheep manure
Dedicated Energy Crops	Dry lignocellulosic wood energy crops	Short-rotation willow, poplar, eucalyptus
	Dry lignocellulosic herbaceous energy crops	Miscanthus, switchgrass, common reed, giant reed
	Oil energy crops	Flax, hemp, tobacco stems, aquatic plants (lipids from algae)
	Starch energy crops	Wheat, potatoes, maize, barley, triticale, amaranth
Forestry	Forestry by-products	Bark, woodblocks, wood chips from tops and branches, logs from thinning
Industry	Wood industry residues	Sawdust, wood chips, slabs, off-cuts
	Food industry residues	Beet root tails, used cooking oils, slaughterhouse waste
	Industrial products	Pellets, briquettes, bio-oil, ethanol, biodiesel
Park and Garden Waste	Herbaceous, woody, contaminated waste	Grass, pruning, demolition wood, biodegradable municipal waste
Others	Roadside hay, husks/shells	Almond, olive, walnut, palm pit, cacao

Source: Shankar et al. (2021)

Dry lignocellulosic feedstocks are suitable for thermochemical conversion processes such as gasification, combustion, and liquefaction, while wet lignocellulosic feedstocks are ideal for biological conversion methods like digestion (Okoro et al., 2022).

III. DIAGRAMATICAL EXPLANATION OF CYCLE OF BIOMASS ENERGY



Biomass Utilization for Energy Production

Biomass energy is primarily derived from wood and agricultural products, with sawdust, wood chips, and bark accounting for approximately 44% of biomass energy (Ikechukwu et al., 2023). Agricultural waste materials such as corncobs and fruit pits also serve as valuable biomass sources.

Electricity generation from wood and wood waste is common in paper and sawmills, where waste materials are used to produce steam and electricity (Nwosu et al., 2021). Solid waste, including municipal trash, can be converted into energy through combustion. The thermal energy of one ton of trash is equivalent to 500 pounds of coal, although non-biomass components like plastics reduce its overall energy efficiency (Adeyemi et al., 2023). Waste-to-energy plants operate similarly to coal-fired plants, utilizing flammable waste as fuel.

Biogas and landfill gas are additional biomass energy sources. Methane gas, produced during the decomposition of organic matter, can be collected and refined for use as fuel. Modern regulations mandate the collection of methane gas from landfills to mitigate environmental and safety risks (Okafor et al., 2022).

IV. Experimental Studies on Biomass Briquettes

Kyauta et al. (2021) investigated the pelletization of maize cobs and groundnut shells using a densification process. The materials were compressed at a minimum pressure of 275 bars and molded into pellets measuring 12.5 mm in diameter and 13 mm in length. The study evaluated moisture content, ash content, combustion rate, and calorific values. Groundnut shells exhibited a higher combustion temperature, with calorific values of 13.9 MJ/kg compared to 13.8 MJ/kg for maize cobs. The findings suggest that these pellets can provide sufficient heat for domestic use when paired with appropriate appliances.

Burubai et al. (2022) examined the impact of moisture content on the heating values of groundnut shells, maize cobs, coconut shells, and palm kernel shells using a bomb calorimeter. The results indicated that heating values decreased as moisture content increased. For instance, groundnut shells exhibited a heating value of 18.795 MJ/kg at 9.34% moisture content, which dropped to 9.65 MJ/kg at 24.0% moisture content. Similar trends were observed for maize cobs, coconut shells, and palm kernel shells. Despite lower heating values compared to maize cobs, groundnut shells remain a viable energy source when processed using appropriate technologies.

V. Conclusion

This study reviewed the calorific values of briquettes made from maize cobs and groundnut shells, highlighting their potential as alternative heating fuels. Groundnut shells demonstrated higher energy values during combustion compared to maize cobs. The utilization of agricultural waste for energy production not only addresses the growing demand for sustainable energy but also contributes to environmental preservation by reducing waste and deforestation.

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