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Characterization of Sludge, Water Hyacinth, and Bagasse as Potential Feedstocks for Briquette Fuel

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Abstract: The growing demand for sustainable energy has driven interest in biomass and waste-derived fuels as alternatives to fossil fuels. This study evaluates water hyacinth, bagasse, and wastewater sludge as potential feedstocks for briquette fuel production through analysis of their combustion characteristics. The materials were collected, dried, and size-reduced to achieve uniform particle distribution. Proximate analysis was conducted to determine moisture content, ash content, and volatile matter using standard ASTM methods, while calorific values were measured using a bomb calorimeter. Elemental composition (C, H, N, S, and O) was also analyzed to assess fuel quality. Drying significantly enhanced the fuel properties of all samples, reducing moisture content to approximately 9–10%. This resulted in marked increases in calorific values to 19 MJ/kg for water hyacinth, 18.2 MJ/kg for bagasse, and 16.2 MJ/kg for sludge. Volatile matter increased substantially, indicating improved combustibility, while ash content varied, with bagasse exhibiting the lowest values. Overall, dry samples demonstrated superior energy performance compared to wet materials. The results confirm that these biomass resources are viable alternative energy sources when properly processed, offering a sustainable solution for waste management and renewable energy production. Overall, the findings demonstrate that these biomass resources are viable alternative fuels when properly processed, with bagasse showing superior combustion efficiency due to lower ash content, while water hyacinth and sludge also exhibit strong potential for sustainable energy production and waste management.

Keywords: *Bagasse; Biomass; Briquettes; Renewable Energy; Sludge; Water Hyacinth.*

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I. INTRODUCTION

The rising global demand for sustainable and environmentally friendly energy sources has intensified research into biomass and waste-derived fuels as viable alternatives to fossil fuels [1] Among the promising materials are water hyacinth, bagasse, and wastewater sludge, which are abundant, low-cost, and possess considerable energy potential. However, their effective utilization as fuels depends significantly on appropriate raw material preparation, moisture reduction, and a detailed understanding of their combustion characteristics. Water hyacinth (*Eichhornia crassipes*), an invasive aquatic plant prevalent in many African water bodies, poses serious ecological and economic challenges. Its high moisture content, often exceeding 80% in raw form, limits its direct use as a fuel, making drying a critical pre-treatment step to enhance its combustibility and calorific performance [2] Bagasse, the fibrous residue from sugarcane processing, is widely recognized as an efficient biomass fuel due to its relatively high calorific value, typically ranging from 16.87 to 18.64 MJ/kg. Nevertheless, its combustion efficiency is influenced by moisture content and particle size distribution, which necessitate controlled drying and proper size reduction [3]

Similarly, wastewater treatment sludge represents a significant disposal challenge due to its high moisture and ash content. Despite this, sludge contains substantial organic matter, with reported calorific values around 17.07 MJ/kg, indicating its potential as a renewable energy resource when adequately processed [4]. Proper drying is essential to reduce moisture content, improve ignition properties, and enhance overall combustion efficiency.

The preparation of these biomass materials typically involves drying under controlled temperature conditions to achieve optimal moisture levels, followed by size reduction to ensure homogeneity. These processes play a crucial role in determining key combustion characteristics such as ignition behavior, burning rate, and heat release efficiency. Furthermore, proximate analysis and ultimate analysis was conducted including moisture content, ash content, volatile matter, and fixed carbon and carbon, hydrogen, nitrogen, Sulfur and oxygen respectively are fundamental in assessing the fuel quality and combustion performance of each material.

This study, therefore, focuses on the preparation and drying of water hyacinth, bagasse, and sludge, and the evaluation of their individual combustion characteristics. By analyzing each material independently, the study provides a comparative understanding of their fuel properties and highlights their potential for application as alternative energy sources. A study by [5] highlighted the importance of feedstock composition, moisture content, and elemental characteristics in determining combustion performance. Proper preparation of biomass, such as drying or other pre-treatment methods, can increase fixed carbon content and calorific value, which are critical for efficient energy conversion. The study recommended further investigation into preparation techniques to reduce volatile matter and emissions during combustion. [6] noted that pre-treatment, including carbonization, significantly influences the combustion characteristics of biomass. Treated materials showed higher calorific values and lower emissions compared to untreated samples, although some methods, like carbonization, may reduce overall energy yield, indicating the need for careful selection of preparation methods [7].

This research focuses on the preparation of raw biomass materials, including water hyacinth and bagasse, to improve their combustion efficiency and environmental performance. Addressing this stage is essential for developing a cost-effective, cleaner, and sustainable energy source.

- *Theoretical Background*

Biomass combustion is governed by several physicochemical properties that determine fuel performance, including moisture content, volatile matter, ash content, fixed carbon, and calorific value. [8]These properties are commonly evaluated through proximate and ultimate analyses. Moisture content plays a critical role in combustion efficiency, as high moisture reduces ignition ability and lowers net energy output.[9] Studies indicate that reducing moisture content below 15% significantly enhances calorific value and combustion performance . Volatile matter represents the fraction of biomass that vaporizes during heating and contributes to flame formation.[10] Higher volatile matter content generally improves ignition and combustion behavior, although excessive values may lead to rapid burning and instability. Ash content refers to the inorganic residue remaining after combustion. High ash content reduces fuel efficiency and may cause operational challenges such as slagging and fouling in combustion systems. [11]Therefore, materials with low ash content are preferred for energy applications. Calorific value is the most important indicator of fuel quality, representing the amount of heat released during combustion. [12]Biomass briquettes typically exhibit calorific values ranging between 16 and 25 MJ/kg depending on composition and processing conditions.

- *Industrial Sludge*

Industrial sludge originates from a range of activities, including manufacturing, mining operations, and energy production processes. The characteristics of industrial sludge are highly variable, depending on the specific industry, with contaminants like organic or inorganic pollutants, heavy metals, and hazardous chemicals. [13]It is often treated to recover valuable materials or reduce toxicity, and disposal may involve incineration or secure land-filling.

- *Water Hyacinth*

Water hyacinth (*Eichhornia crassipes*) is an abundant and renewable aquatic plant, particularly in tropical and subtropical regions. Known for its rapid growth, it can double in size within a few weeks under ideal conditions, ensuring a steady supply for use in various applications[14]. In Kenya, for instance, it has overrun Lake Victoria, posing challenges to ecosystems and local livelihoods but also offering an opportunity as a readily available resource[15]. Its removal not only provides raw material for energy purposes, but also helps improve water quality due to its pollutant-absorbing capabilities. Despite the benefits of its utilization, managing the plant’s invasive spread remains a significant challenge. Nonetheless, water hyacinth stands out as a resource with considerable potential for sustainable development and has practical uses, one of which is its role in briquette production. It will be obtained from Lake Victoria and dried to 15% moisture content.[16]. Drying water hyacinth to very low moisture levels, such as 8%, can negatively affect its physical properties and handling.[17] Excessive drying makes the fibers rigid and more prone to breakage or fragmentation during processing. It also increases energy consumption during the drying phase and can generate excessive dust, which poses occupational health and safety risks and may reduce efficiency in downstream thermal processing or combustion preparation.[18]

- *Characteristics of Water Hyacinth*:

Water hyacinth is known for its high biomass production, as it grows rapidly, making it a sustainable source of biomass for energy applications [19], [20]. It has a high moisture content, which requires proper drying before any thermal processing or combustion. Its composition, including cellulose and lignin, affects its structural properties and handling during preparation. Water hyacinth also has a relatively low ash content compared to other biomass sources, resulting in minimal residue upon combustion[21]. Additionally, harvesting water hyacinth for energy purposes can provide environmental benefits by controlling its overgrowth and mitigating its negative impacts on water bodies. Proper preparation and drying of water hyacinth are therefore essential to ensure efficient handling, storage, and energy recovery during combustion or other thermal processing applications.

- *Bagasse*

Bagasse is the fibrous material that remains after the juice has been extracted from sugarcane. Commonly found in sugar mills as a byproduct of sugar production [22]. It is a lignocellulosic material with a fibrous and porous structure, light brown in color, and has a low bulk density ranging between 150-200 kg/m³. Chemically, bagasse is composed of cellulose (40-50%), hemicellulose (25-35%), lignin (15-25%), and a small percentage of ash (1-4%) [23]. Fresh bagasse contains about 40-50% moisture and has a calorific value of 7.5-9.2 MJ/kg, making it an excellent bio-fuel source. It is biodegradable and decomposes naturally under microbial activity. The primary sources of bagasse are sugar mills, where it is obtained after crushing sugarcane. It is widely used in various industries, including the paper and pulp industry for manufacturing paper, the bio fuel sector for generating electricity and bio ethanol, and agriculture, where it is sometimes processed into cattle feed or compost. Due to its potential applications, various treatment methods are employed to improve its usability and efficiency. Physically, bagasse is treated through drying to reduce moisture content, grinding and milling to decrease particle size, and pelletization to convert it into compact fuel pellets [24]. Chemically, it undergoes alkaline treatment to enhance digestibility in animal feed and bio fuel production, acid hydrolysis to break down cellulose into fermentable sugars for ethanol production, and bleaching in paper manufacturing to improve quality. Biological treatment methods include enzymatic hydrolysis, which converts lignocellulose into bio ethanol, composting to produce organic fertilizer, and microbial fermentation for biogas production [25]. Additionally, thermal treatment techniques such as combustion in boilers for power generation, pyrolysis to produce bio char and bio-oil, and gasification for syn gas production further enhance its usability [26]. Bagasse is a versatile and sustainable byproduct with significant potential in multiple industries [27]. Effective treatment methods not only improve its efficiency but also contribute to waste reduction and sustainable energy production, making it a crucial resource in environmentally friendly industrial processes.[28].

- *Characteristics of Sludge, Hyacinth and Bagasse*

- *Combustion Characteristics*

✓ *Calorific Value*

The calorific value of biomass, which indicates its energy content, was determined using a Parr 6200 oxygen bomb calorimeter (Parr Instrument Company, Moline, IL) [29]. A 1-gram sample of the sludge was placed in a stainless-steel crucible within the combustion vessel. Ignition was initiated via a 2223 cotton fuse, and the vessel was pressurized with oxygen, encased in a water jacket. Upon ignition, the heat released by the combustion process was then transferred to the water jacket. The calorimeter then calculated the heating value of the sample by measuring the temperature increase in the water.

✓ *Ash Content*

The standard method that was used was ASTM 03174-97 (39) as per [30]. In this procedure, an empty crucible was heated to 650°C for 30 minutes in a muffle furnace, then covered and allowed to cool over a desiccant for one hour. Subsequently, one gram of the sample was placed into the weighed crucible, covered, and gradually heated to 725°C over a period of two hours. The crucible was then cooled in desiccators before being weighed, with the difference in mass indicating the ash content.

✓ *Volatile Matter*

The determination of volatile matter followed the ASTM E872-82 (2006) standard, as specified by [31]. One-gram sample was weighed and placed into a crucible. The crucible with the sample was then be heated in a furnace at 950 °C for 7 minutes. It was then be removed, cooled in desiccators, and weighed. The difference in mass represented the volatile matter.

II. MATERIALS AND METHODS

- *Study Area and Materials*

The study was conducted at Egerton University, located in Nakuru County, Kenya. Water hyacinth was collected from Lake Victoria, sludge was obtained from a wastewater treatment plant in Nakuru, and bagasse was sourced from West Kenya sugar company.

- *Sample Preparation*

The collected materials were washed to remove impurities and dried to reduce moisture content. Drying is a critical pre-treatment step that enhances combustion efficiency and improves fuel quality. The dried samples were then ground and sieved to obtain a uniform particle size of 2 mm to 11mm for analysis.

- *Proximate Analysis*

Proximate analysis was conducted to determine moisture content, ash content, and volatile matter using standard ASTM procedures. Moisture content was determined in accordance with ASTM Standard D 3173-87 (1998) standard by oven drying the samples at 105°C until a constant weight was achieved. Ash content was determined using ASTM 03174-97, where samples were combusted in a muffle furnace at temperatures of approximately 650–750°C to obtain the inorganic residue. Volatile matter was measured following ASTM 03174-97 by heating the samples at 950°C for a specified duration in the absence of air.

- *Elemental Analysis*

Ultimate analysis was conducted to determine the elemental composition (C, H, N, S), while oxygen content was calculated by difference. Elemental composition is crucial in assessing fuel quality and predicting combustion performance.

- *Study Procedures*

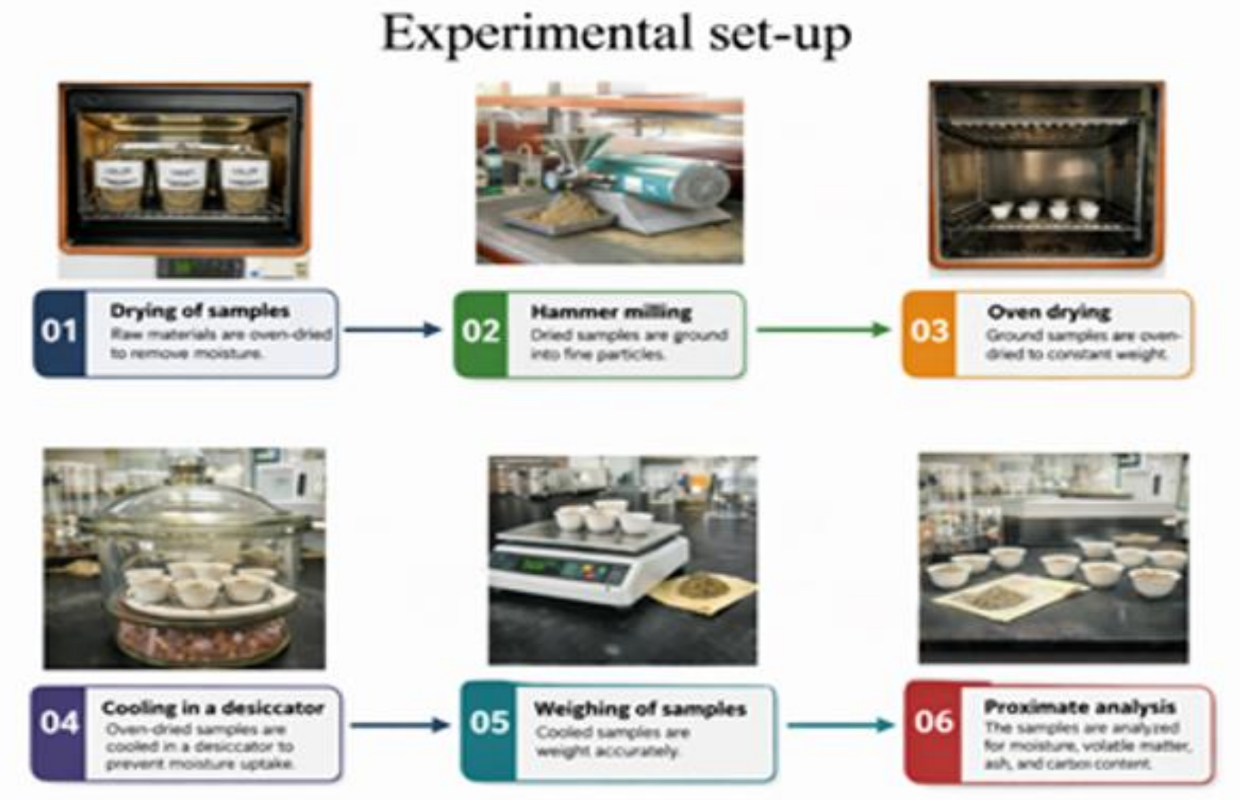

Fig 1 Experimental Setup for Biomass Sample Preparation and Characterization

- *Combustion Characteristics and Properties of Water Hyacinth, Bagasse with Sludge*

To evaluate the combustion characteristics and properties of water Hyacinth, Bagasse with Sludge, both experimental and field procedures was conducted. Experimentally, raw materials were collected from wastewater treatment plants (sludge), water bodies (hyacinth), and sugar mills (bagasse). The materials underwent a drying process to minimize their moisture content, followed by grinding to achieve consistent particle sizes suitable for analysis. Proximate analysis, including moisture content, volatile matter, ash content, and calorific value determination, were performed using standard ASTM methods. Additionally, ultimate analysis was conducted using a CHNS analyzer to analyze the elemental composition (C, H, O, N, and S) of each material. Calorific value was measured using a bomb calorimeter. Field procedures involved site selection for sample collection and oven drying of materials. In addition to proximate analysis, elemental ultimate analysis was also be carried out.

- *Determination of Moisture Content*

Moisture content was measured in accordance with the the ASTM Standard D 3173-87 (1998). Empty crucible was first heated to 105°C for 1 hour, then removed from the oven, covered, and cooled in a desiccant for 30 minutes. Each sample, weighing one gram, was placed in the crucibles and dried in an oven at 105°C for 24 hours. The crucibles were then cooled to room temperature in desiccators and weighed again, with the mass difference indicating the moisture content.

$$Moisture\ content = \frac{Wet\ sample - Dry\ sample}{wet\ sample} * 100\ \% \qquad 3.1$$

- *Determination of Calorific Value*

The calorific value of biomass, which indicates its energy content, was determined using a Parr 6200 oxygen bomb calorimeter (Parr Instrument Company, Moline, IL). A 1-gram sample of the sludge was placed in a stainless-steel crucible within the combustion vessel. Ignition was initiated via a 2223 cotton fuse, and the vessel pressurized with oxygen, encased in a water jacket. Upon ignition, the heat released by the combustion process then transferred to the water jacket. The calorimeter then calculated the heating value of the sample by measuring the temperature increase in the water.

- *Determination of Ash Content*

The ash content in fuel acts as a measure of the suitability of blends made from water hyacinth, bagasse with sludge briquettes as a reliable source of fuel. The standard method that was used was ASTM 03174-97 (39) . In this procedure, an empty crucible was heated to 650°C for 30 minutes in a muffle furnace, then covered and allowed to cool for one hour over a desiccant. Subsequently, a sample of one gram was placed into the weighed crucible, covered, and gradually heated to 725°C over a period of two hours. The crucible was then cooled in desiccators before being weighed, with the difference in mass indicating the ash content

$$Ash\ Content\ \% = \frac{(Crucible\ weight+Ash)-(Weight\ of\ Crucible)}{(Weight\ of\ crucible+Sample)-(Weight\ of\ crucible)} * 100\ \% \qquad 3.3$$

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

- *Determination of Volatile Matter*

The determination of volatile matter followed the ASTM E872-82 (2006) standard. One-gram sample was weighed and put into a crucible. The crucible with the sample was then heated in a furnace at 950 °C for 7 minutes. It was then taken out, cooled in desiccators, and weighed. The mass difference indicated the amount of volatile matter.

$$Volatile\ matter = \frac{Crucible\ weight + sample - Crucible\ weight + Dry\ sample}{Crucible\ weight + Sample} * 100\ \% \qquad 3.4$$

III. RESULTS AND DISCUSSION

➢ *Preparation of Sludge, Hyacinth and Bagasse and Determination of the Combustion Characteristics and Properties.*

- *Proximate Analysis*

✓ *Water Hyacinth*

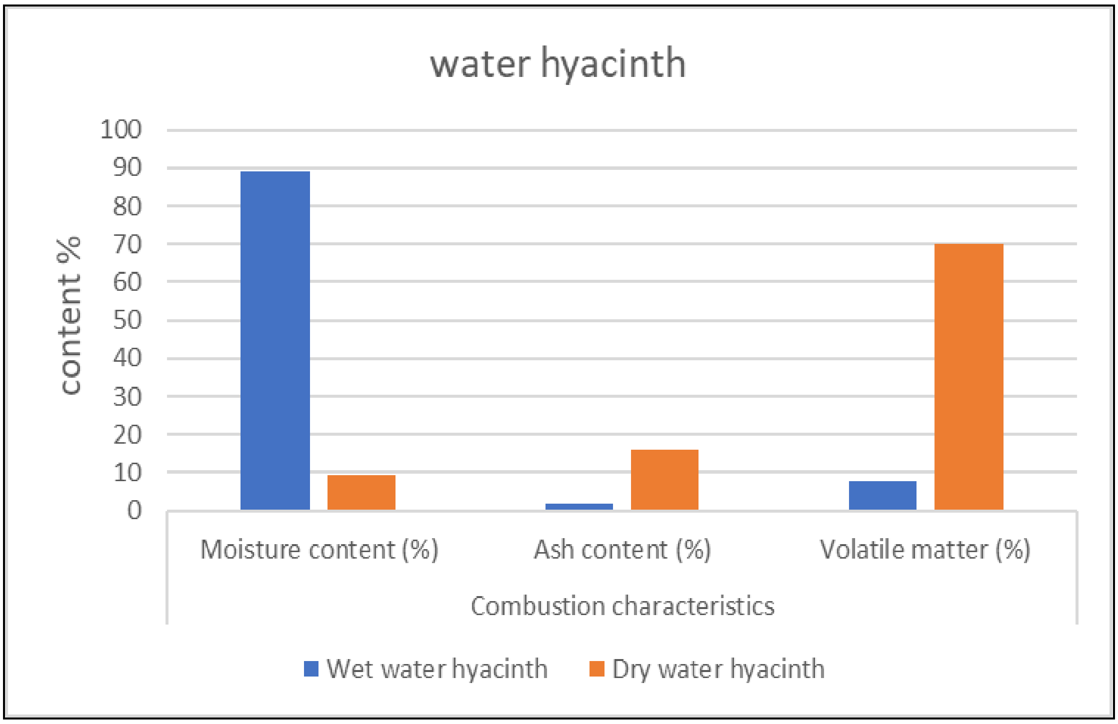

Fig 1 Presents a Comparative Analysis of the Combustion Properties of Water Hyacinth Under Wet and Dry Conditions

Moisture content drops sharply from 89% in the wet form to 9.4% when dried. Ash content also rises from 1.76% to 16%, and volatile matter shows a substantial increase. Overall, the dry water hyacinth exhibits superior fuel characteristics, making it more practical for briquette production and energy applications than the wet form.

- ✓ *Bagasse*

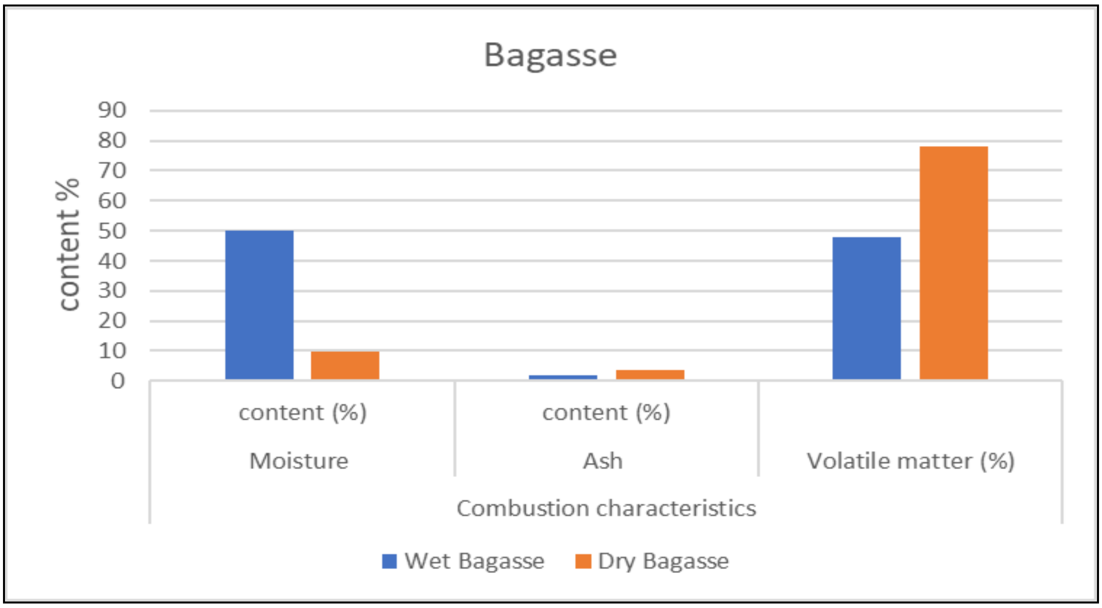

Fig 2 Shows a Comparative Analysis of the Combustion Properties of Bagasse Under Wet and Dry Conditions

In the wet weight state, bagasse contains a moisture content of 50%, indicating that half of its weight is water The ash content is relatively low at 1.8%, suggesting minimal inorganic residue after combustion. Additionally, volatile matter is 48%, pointing to decent combustion characteristics. In the dry weight state, the moisture content drops significantly to 9.8%, since dry basis percentages look smaller after drying.

- ✓ *Sludge*

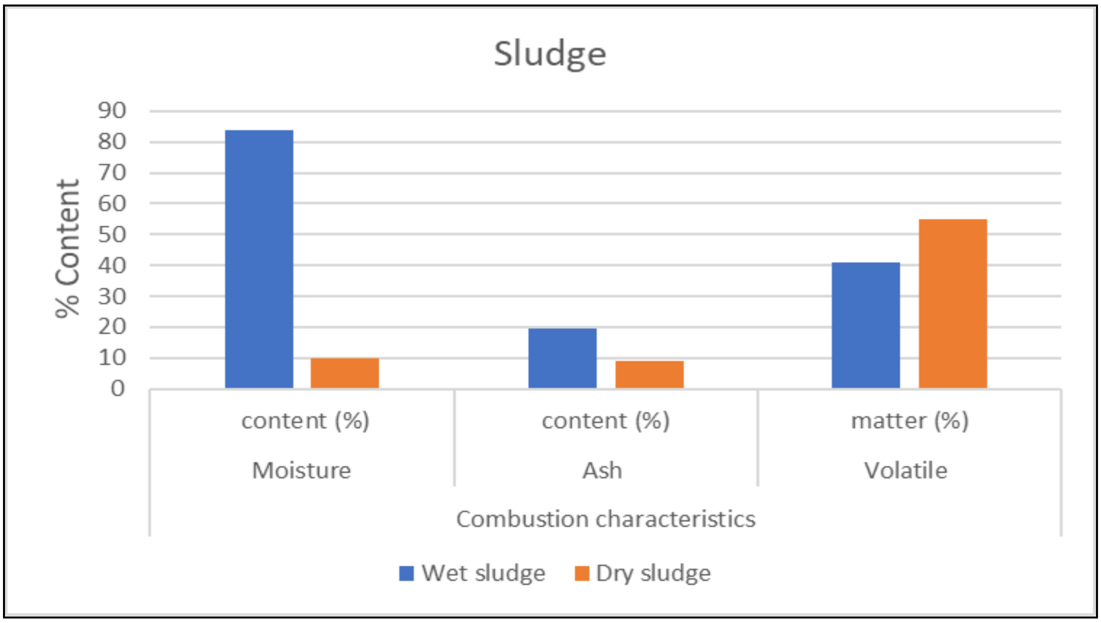

Fig 3 Shows a Comparative Analysis of the Combustion Properties of Sludge Under Wet and Dry Conditions

On a wet weight basis, sludge contains a high moisture content of 84%, which significantly limits its energy efficiency. In the dry weight condition, the moisture content drops to 9.93%, resulting in a much-improved calorific value of 18.2 MJ/kg. When comparing the two states, it is clear that drying the sludge significantly improves its suitability as a biofuel.

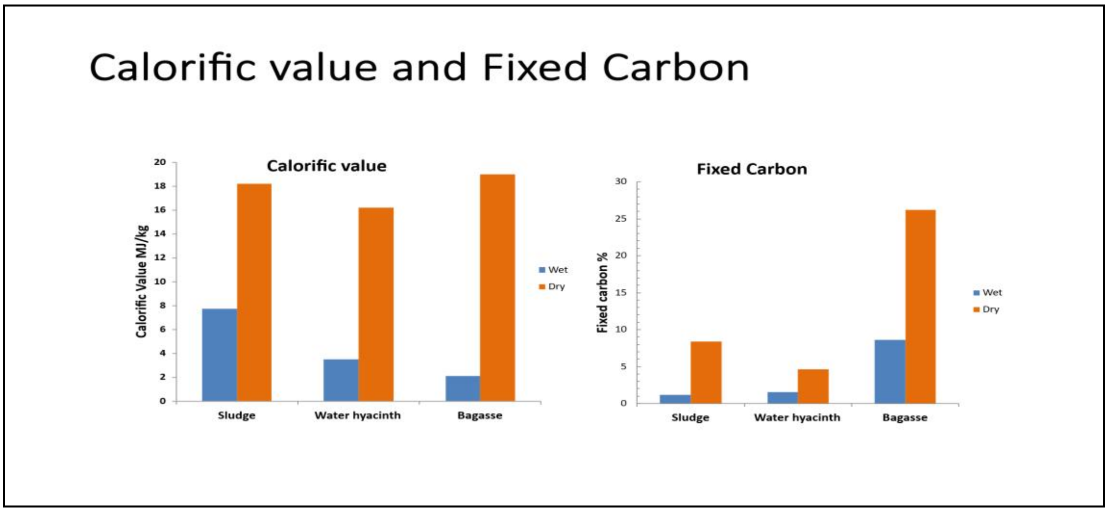

Fig 4 Shows the Calorific Value and Fixed Carbon Contents of Sludge, Water Hyacinth, and Bagasse Under Wet and Dry Conditions.

The graphs compare the performance of wet and dry biomass samples; sludge, water hyacinth, and bagasse—in terms of calorific value and fixed carbon content. The results clearly show that drying significantly enhances the fuel properties of all the materials. In the calorific value analysis, dry samples exhibit much higher energy output compared to their wet counterparts, with sludge increasing from 7.7 MJ/kg to 18 MJ/kg, water hyacinth from 3.5 MJ/kg to 16.2 MJ/kg, and bagasse from 2.09 MJ/kg to 19 MJ/kg.

This improvement is attributed to the removal of moisture, which otherwise consumes a significant portion of the heat energy during evaporation, thereby reducing the effective energy available for combustion. Among the materials, dry bagasse demonstrates the highest calorific value, indicating its superior potential as a biofuel feedstock, while wet water hyacinth shows the poorest performance due to its inherently high moisture content. A similar trend is observed in fixed carbon content, where dry samples again outperform wet ones. Fixed carbon increases from about 1% to 8% for sludge, 1.5% to 4.5% for water hyacinth, and 8.5% to 26% for bagasse. Higher fixed carbon indicates better char formation and sustained combustion, meaning that dry bagasse not only releases more energy but also burns more steadily over time. Overall, the findings confirm that drying is a critical preprocessing step in biomass utilization, as it enhances both the energy content and combustion quality of the materials. Consequently, dry bagasse emerges as the most efficient fuel among the tested samples, whereas wet water hyacinth is the least suitable without prior treatment.

- *Elemental Analysis*

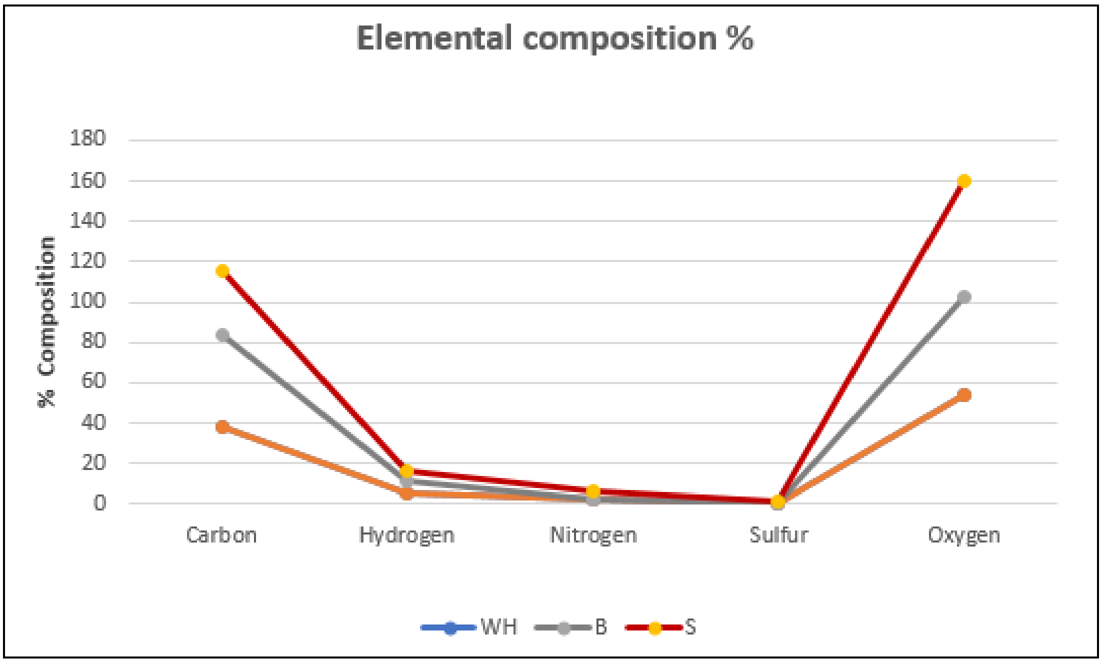

Fig 5 Shows the elemental composition percentage variation of water Hyacinth, Bagasse and Sludge.

The graph presents the elemental composition (%) of three biomass materials; bagasse, sludge and water hyacinth in terms of carbon, hydrogen, nitrogen, sulfur, and oxygen. Sludge exhibits the highest carbon content among the samples, followed by bagasse, while water hyacinth shows the lowest, indicating that sludge may possess a relatively higher energy potential due to its greater carbon fraction. Hydrogen content is comparatively low across all materials, with only slight variations, suggesting a limited but consistent contribution to combustion characteristics. Nitrogen levels are minimal in all cases, although sludge shows a slightly higher proportion, which may imply a marginal increase in potential NOx emissions during thermal conversion. Sulfur content is nearly negligible for all three materials, an advantageous property as it minimizes the risk of sulfur dioxide emissions and associated corrosion issues. Oxygen content is notably high in all samples, particularly in sludge, followed by bagasse and water hyacinth; this is characteristic of biomass fuels and generally corresponds to lower calorific values due to the partially oxidized nature of the material. Overall, the results indicate that sludge is relatively richer in carbon and oxygen, bagasse demonstrates moderate and balanced elemental composition, while water hyacinth contains lower carbon content, which may limit its energy yield despite its environmentally favorable low nitrogen and sulfur composition.

Table 1 Combustion Characteristics of Water Hyacinth, Bagasse, and Sludge Under Wet and Dry Conditions

Biomass	Condition	Moisture Content (%)	Calorific Value (MJ/kg)	Ash Content (%)	Volatile Matter (%)
Water hyacinth	Wet	89	3.5	1.76	7.70
Water hyacinth	Dry	9.4	16.2	16.0	70
Bagasse	Wet	50	2.09	1.8	48
Bagasse	Dry	9.8	18.0	3.8	78
Sludge	Wet	84	7.7	19.5	41
Sludge	Dry	9.93	18.2	8.9	55

IV. ACKNOWLEDGMENT

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➢ *Abbreviations and Acronyms*

- ASTM – American Society for Testing and Materials (ASTM International)
- CHNS – Carbon, Hydrogen, Nitrogen, Sulfur elemental analyzer
- MJ/kg – Megajoules per kilogram (unit of calorific value)
- Kg/m³ – Kilograms per cubic meter (unit of density)
- NO_x – Nitrogen oxides
- SO_2 – Sulfur dioxide

REFERENCES

[1]. B. Gajdzik, M. Jaciow, K. Hoffmann-Burdzińska, R. Wolny, R. Wolniak, and W. W. Grebski, “Impact of economic awareness on sustainable energy consumption: results of research in a segment of polish households,” Energies, vol. 17, no. 11, p. 2483, 2024.

[2]. M. Madhumidha, P. Benish Rose, V. Nagabalaji, I. Das, and S. Srinivasan, “Critical assessment of biorefinery approaches for efficient management and resource recovery from water hyacinths for sustainable utilization,” Rev. Environ. Sci. Biotechnol., vol. 23, no. 2, pp. 443–469, 2024.

[3]. M. Manickavasagam, T. Elango, L. Selvarajan, and K. Elangovan, “Maximizing sustainable power: improving bagasse drying efficiency in Indian sugar mills,” Biomass Convers. Biorefinery, vol. 14, no. 17, pp. 21579–21601, 2024.

[4]. S. Mittapalli et al., “Wastewater Sludge as Energy Resource: Technoeconomic and Environmental Implications,” J. Environ. Eng., vol. 152, no. 2, p. 03125006, 2026.

[5]. N. A. Sasongko, N. G. Putra, and M. L. D. Wardani, “Review of types of biomass as a fuel-combustion feedstock and their characteristics,” Adv. Food Sci. Sustain. Agric. Agroindustrial Eng. AFSSAAE, vol. 6, no. 2, pp. 170–184, 2023.

[6]. K. Kabango, F. G. D. Thulu, T. Mlowa, C. Chisembe, and C. C. Kaonga, “Effect of carbonisation on combustion characteristics of faecal sludge and sawdust blended briquettes,” Environ. Sustain., vol. 6, no. 3, pp. 331–339, 2023.

[7]. C. Li et al., “Sustainable production of porous carbon from biomass: influence of pre-carbonization on pore evolution and environment impact,” Chem. Eng. J., vol. 480, p. 148176, 2024.

[8]. L. Bianchini, A. Colantoni, R. Venanzi, L. Cozzolino, and R. Picchio, “Physicochemical properties of forest wood biomass for bioenergy application: A review,” Forests, vol. 16, no. 4, p. 702, 2025.

[9]. Y. Lai et al., “Characterisation of wood combustion and emission under varying moisture contents using

multiple imaging techniques," Fuel, vol. 373, p. 132397, 2024.
[10]. B. Esteves, U. Sen, and H. Pereira, "Influence of chemical composition on heating value of biomass: a review and bibliometric analysis," Energies, vol. 16, no. 10, p. 4226, 2023.
[11]. J. Luan, Q. Wang, D. Shao, B. Cui, P. Han, and Q. He, "Research progress on influencing factors and control methods of slagging in biomass combustion," Front. Energy Res., vol. 13, p. 1634354, 2025.
[12]. S. Maksymiuk, I. Rybitskyi, O. Karpash, V. Tsykh, and Y. Doroshenko, "Method for Estimating the Calorific Value of Natural Gas for Branched Networks Using Express Quality Control Tools," in Systems, Decision and Control in Energy VI: Volume I: Energy Informatics and Transport, Springer, 2024, pp. 305–328.
[13]. C. Wang, M. Chen, L. Zhou, Y. Hou, P. Zhao, and D. Che, "Correlations of chemical properties of sludge: A comparison study between municipal sludge and industrial sludge," J. Energy Inst., vol. 108, p. 101202, 2023.
[14]. S. Mittapalli et al., "Wastewater Sludge as Energy Resource: Technoeconomic and Environmental Implications," J. Environ. Eng., vol. 152, no. 2, p. 03125006, 2026.
[15]. F. O. Masese, E. W. Wanderi, and H. N. Nyangweso, "Challenges and strategies for management and conservation of water resources and freshwater biodiversity in the Lake Victoria Basin," Front. Conserv. Sci., vol. 6, p. 1544429, 2025.
[16]. A. Ainemukama, "An experimental study to assess the energy potential of blending water hyacinth with other feedstocks for briquette production," 2025.
[17]. D. T. Nega, A. V. Ramayya, M. M. Afessa, and F. Manenti, "Invasive water hyacinth challenges, opportunities, mitigation, and policy implications: The case of the Nile Basin," Florist. Divers.-Biol. Conserv., 2022.
[18]. R. L. Rupasinghe, P. Perera, R. Bandara, G. Kanishka, H. Amarasekera, and R. Vlosky, "Sustainable Energy from Biomass Waste: Evaluating the Feasibility of Sawdust, Sewage Sludge, and Water Hyacinth in Mixed-Pellet Production," For. Prod. J., vol. 76, no. 1, pp. 71–85, 2026.
[19]. S. Kwofie, G. Osei, C. Nyamekye, R. Arthur, R. Quansah, and D. Bryniok, "Water hyacinth as a potential bioenergy resource for woodfuel replacement in communities along the Volta lake in Ghana," Waste Biomass Valorization, vol. 14, no. 7, pp. 2211–2224, 2023.
[20]. A. B. D. Nandiyanto et al., "Progress in the utilization of water hyacinth as effective biomass material," Environ. Dev. Sustain., vol. 26, no. 10, pp. 24521–24568, 2024.
[21]. G. L. Debel et al., "Utilization of water hyacinth briquette as an alternative energy source to combat blooming in Abaya and Chamo Lakes, Ethiopia," BMC Environ. Sci., vol. 3, no. 1, p. 5, 2026.
[22]. N. Ungureanu, V. Vlăduț, and S.-Ștefan Biriș, "Sustainable valorization of waste and by-products from sugarcane processing," Sustainability, vol. 14, no. 17, p. 11089, 2022.
[23]. N. Sylvere, T. Omar, A. Youness, L. El Farissi, and G. Lina, "Innovative applications of sugarcane bagasse in the global sugarcane industry," Processes, vol. 13, no. 12, p. 3796, 2025.
[24]. I. M. Matasyoh, "Characterization, Evaluation and Performance Optimization of Wheat Straw–Bagasse Fuel Pellets," 2024.
[25]. S. Meenakshisundaram, A. Fayeulle, E. Léonard, C. Ceballos, X. Liu, and A. Pauss, "Combined biological and chemical/physicochemical pretreatment methods of lignocellulosic biomass for bioethanol and biomethane energy production—a review," Appl. Microbiol., vol. 2, no. 4, pp. 716–734, 2022.
[26]. V. Pelagalli et al., "Pyrolysis of municipal sewage sludge: Challenges, opportunities and new valorization routes for biochar, bio-oil, and pyrolysis gas," Environ. Sci. Water Res. Technol., vol. 10, no. 10, pp. 2282–2312, 2024.
[27]. A. M. Shabbirahmed et al., "Sugarcane bagasse into value-added products: a review," Environ. Sci. Pollut. Res., vol. 29, no. 42, pp. 62785–62806, 2022.
[28]. H. S. Kusuma, D. Permatasari, W. K. Umar, and S. K. Sharma, "Sugarcane bagasse as an environmentally friendly composite material to face the sustainable development era," Biomass Convers. Biorefinery, vol. 14, no. 21, pp. 26693–26706, 2024.
[29]. D. Gheorghe and A. Neacsu, "The influence of additives upon the energetic parameters and physicochemical properties of environmentally friendly biomass pellets," J. Mex. Chem. Soc., vol. 68, no. 3, pp. 438–454, 2024.
[30]. W. T. Tomen, B. S. Diboma, B. V. Bot, and J. G. Tamba, "Physical and Combustion properties investigation of hybrid briquettes from tropical Sawdust: Case study of Iroko (Milicia excelsa) and Padouk (Pterocarpus soyauxii)," Energy Rep., vol. 9, pp. 3177–3191, 2023.
[31]. C. E. Umeocho, K. C. Ezejiegu, C. Q. Ujabike, T. U. Onuegbu, and V. C. Eze, "Enhancement of the mechanical properties of sawdust briquette using mung beans waste," Mater. Eng. Res., vol. 6, no. 1, pp. 332–340, 2024.
[32]. A. Ndecky, P. W. Tavares, A. Senghor, M. Kane, H. Ndiath, and I. Youm, "Proximate analysis of alternatives cooking solides fuels in sub saharan by using astm standards," Int J Clean Coal Energy, vol. 11, no. 01, pp. 1–12, 2022.
[33]. K. Rueangsan, P. Kraisoda, S. Phansomboon, S. Trisupakitti, T. Rudchapo, and M. Punon, "From Waste to Energy: Briquette Fuel Production from Coconut Powder and Palm Residue for Sustainable Energy Applications," Eng. Sci., vol. 38, p. 1900, 2025.