

Characterization of Waste Bamboo Leaves for its Valorization Potential as Sustainable Material

¹Kehinde, T.O., ²Ojoawo S.O., ³Alade A.O and ⁴Oguntola, I. O.

^{1,2}Department of Civil Engineering, Federal University of Agriculture and Technology, Okeho, Oyo State, Nigeria

³Department of Chemical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria

⁴Nigerian Building and Road Research Institute, Km 10, Idiroko road, Sango-Ota, Ogun State, Nigeria

Corresponding Author: oguntolaisaiah@nbrri.org.ng Tel:07032743530

Abstract

Waste Bamboo Leaves (WBL) is an available, abundant, sustainable material and a potential environmental pollutant however, it is chemically and fiber-rich. This study investigated the feasibility of valorizing WBL in order to protect the environment. Valorization of WBL is of prime importance for a clean environment and human health. The WBL has no commercial value, and it is usually disposed of by open burning, thus causing environmental pollution and disposal problems have become a growing concern in environmental research. WBL were sourced from a bamboo thicket at Ikoyi, Ogbomoso, Oyo State. The WBL were washed, sun-dried to reduce moisture content. The dried WBL was ground into 50 μ m and stored in airtight containers. The study investigated the proximate and ultimate analysis of the WBL. The raw WBL was characterized using Scanning Electron Microscopy (SEM), X-ray diffraction (XRD), X-ray Fluorescence (XRF) for morphology, crystallinity and chemical composition, respectively. The waste Bamboo Leaves Ash (WBLA) were also characterized using XRF. The WBL consists of high carbon content, which could be a valuable source of energy through combustion / renewable energy. High content of hydrogen in WBL could be suitable for syngas production. The XRF revealed the silicon oxide in WBL and WBLA as 60.42 and 67.34 % respectively. The study is in line with the target of the United Nations' Sustainable Development Goals (SDG) 6, Clean water and sanitation, targeting access to a safe environment.

Keywords: Characterization, Silica, Valorization, Waste Bamboo Leaves.

Introduction

Bamboo is a tribe of flowering perennial evergreen plants in the grass family of *Poaceae* and the subfamily of *Bambusoideae*. The scientific name is *Bambusa*. Bamboo is recognized as the fastest-growing plant in the world (Supee et al., 2022). It is an abundant, inexpensive, renewable resource and is cheap (Jiang-Tiang et al., 2024). Bamboo is an outstanding renewable biomass resource due to its high growth. Waste bamboo leaves (WBL) have no commercial value, and it is usually disposed of by open burning, thus causing environmental pollution and disposal problems. Other constituents in bamboo leaves are cellulose, hemicellulose, lignin, fibrovascular bundles and carbon content (Junidal et al., 2022)

Bamboo leaves have a high silica content; proper use of this silica would help circumvent environmental issues and valorize agricultural waste. Bamboo, which is viewed as a sustainable, low-cost, and abundantly available resource, is suitable for use as an adsorbent. It is high in carbon content and the fibrovascular bundle structure of bamboo consists of epidermis, parenchyma cells, and vascular bundles, which are surrounded by supporting fibers. The unique mechanical properties of bamboo fibers come from their composite structure, in which cellulose fibrils are surrounded by a matrix of mainly lignin and hemicellulose (Sareen and Sibian, 2025). Bamboo Leaves waste could be processed into value-added products such as animal feed, herbal remedies, and bioplastics, which further enhances bamboo as a multifunctional resource that can play a crucial role in addressing ecological challenges. Moreover, bamboo leaves have been utilized in various cultural rituals and artisanal crafts, highlighting their integral role in the heritage and livelihood of communities that depend on this valuable plant throughout generations, thus further enhancing the narrative of bamboo as a vital resource that transcends its utilitarian applications. Bamboo is utilized for

sustainable chemical and materials for innovative technology. Recent trend in the exploration of transforming raw materials into higher-value products is the concern of this study. Waste Bamboo Leaves Ash (WBLA) could serve as pozzolanic material to enhance mechanical performance of fiber in cement for construction ((Jiang-Tiang *et al.*, 2024). There is a significant gap in the literature that requires further exploration, particularly in terms of its nutritional benefits, processing methods, and market opportunities (Sahoo *et al.*, 2021). Many researchers have worked on bamboo leaves, however, there are still few works reporting bamboo ash. This, therefore, established the gap in research and the novelty of the research focus of this study. The objective of this study is to determine the viability of the potential for valorizing WBL. Therefore, in this study, the silica content of the WBLA was determined through characterization which could be used as a green adsorbent for wastewater treatment and as mineral addition with Portland cement during construction (Olawale *et al.*, 2020).

Materials and Methods

The materials and methods adopted in this research are discussed in this section.

Collection of raw material

Bamboo leaves used in this study were collected as waste materials from bamboo thickets in Ikoyi Town, Ogbomoso, Oyo State, Nigeria. (8.142165⁰ N and 4.245186⁰ E). Samples of the collected bamboo leaves were taken to the Herbarium Section of the Pure and Applied Biology Department, LAUTECH, Ogbomoso for identification. The Flowchart of WBL powder developed and analytical procedure is shown in Figure 1.

Characterization of Waste Bamboo Leaves

The pictorial view of WBL and powder WBL are shown in Figure 1. The physicochemical properties of the raw WBL were determined using proximate and ultimate analyses. The flow chart of the analytical procedures are shown in Figure 2.



Figure 1: Pictorial view of (a)WBL (b) Powder WBL

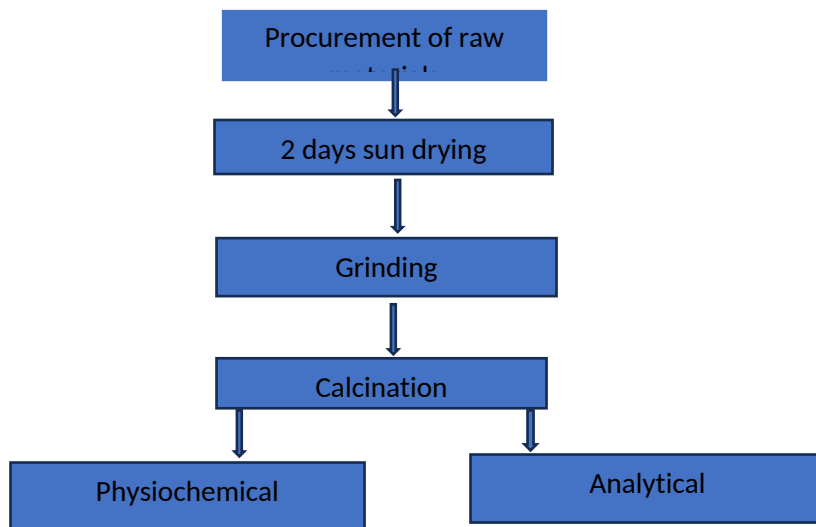


Figure 2: Flowchart of WBL Powder Developed and Analytical Procedure

Determination of proximate composition of the WBL

The proximate analysis enabled the determination of moisture, ash content, crude fibre, crude protein and carbohydrate in the ground bamboo leaves. The ground samples were prepared following Method D and Practice D 7582 ASTM standard. The methods used to carry out the analysis are outlined in this section:

Determination of moisture content of WBL

The moisture content was determined by weighing ground bamboo leaf powder in crucibles without the covers and placing them in the furnace at 105 °C for 2 h. Then remove the specimen crucibles, cover quickly, allow to cool to ambient temperature in a desiccator, and weigh as soon as possible (Ajetunmobi et al., 2021). The percentage of moisture content in the sample analysis was calculated using Equation 1

$$\text{Ash content (\%)} = \frac{m_1 - m_2}{m_1} \times 100 \quad (1)$$

Where: m_1 = weight of specimen used, g and m_2 = weight of specimen after drying in the moisture test (g).

Determination of ash content of WBL

The determination of the ash content of the WBL was carried out by drying and weighing a crucible dish using an analytical balance. Thereafter, 2 g of the ground WBL powder was transferred to the previously dried and weighed crucible dish. The dish plus the sample was placed in the muffle furnace for 3 hours at a temperature of 600 °C. The sample, together with the crucible dish, was removed from the muffle furnace after 3 h and placed immediately in a desiccator to avoid chemical reaction caused by atmospheric humidity while being cooled. The content was weighed after cooling and the ash content was calculated using the relationship given in Equation 2. Ash content (%) =

$$\frac{W_3 - W_1}{W_2 - W_1} \times 100 \quad (2)$$

Where W_3 = weight of ground bamboo leaves, W_2 = weight of heated ground bamboo leaves and W_1 = weight of crucible.

Determination of crude protein of WBL

The Kjeldahl method was used in the determination of the crude protein content of the WBL powder. The basis of this method was the conversion of nitrogenous compounds in the analysed sample to ammonium sulphate through the digestion of the sample with concentrated sulphuric acid in the presence of selenium (Kamya et al., 2022). This method is carried out based on ISO 1871:2009. The 2 g of the ground WBL was put into the digestion flask and half of a selenium-based catalyst tablet was added which was concentrated

sulphuric acid (25 mL), The mixture was heated slowly at 200 °C until the resulting solution was clear, and it was cooled to a temperature of 25 °C.

The digested solution was allowed to cool, then diluted. The digested sample solution was later transferred into a 100 mL volumetric flask and distilled water was added to make up to a specified mark. The distillation apparatus was flushed out before use by boiling distilled water in the steam generator of the distillation apparatus for about 15 minutes. Furthermore, 25 mL of 2 % boric acid was pipetted into a 250 mL conical flask and two drops of mixed indicator were added. Liquid was drained from the steam trap and the stop cock, which drains the steam trap, was left open. The 250 mL conical flask and its contents were placed under a condenser in such a way that the tip of the condenser was completely immersed in the solution. 10 mL of the digested sample was measured and poured into the decomposition flask. An excess of 40% (about 15-20 mL) was added to the decomposition flask. Steam was forced through the decomposition chamber by shutting the stop cock on the steam trap outlet to drive the liberated ammonia into the collection flask (a conical flask containing 25 mL of 2% boric acid) (Ajetunmobi *et al.*, 2021).

The collected solution was titrated with standardized solution until it reaches the endpoint colour change. The endpoint of the titration was identified as the first colour change. Equation (3) was then used to calculate the crude protein of the sample.

$$\% \text{ crude protein} = \frac{V_2 - V_1 \times C_A \times 0.0014 \times 100 \times 6.25}{W_3 \times 10} \times 100 \quad 3$$

Where V_1 is the volume of blank, V_2 is the volume of the sample, C_A is the concentration of the acid and W_3 is the weight of the raw sample WBCP1.

Percentage of crude fibre determination

The WBL was weighed into a round-bottomed flask, and that was followed by the addition of a measured 50 mL fibre solution and the resulting mixture was boiled for 1 h. Filter paper was then used to filter the mixture through the use of vacuum pump to suck the liquid and distilled water to wash it till it became clear. The residue was scraped into crucible and dried in an oven for 24 h and weighed. Thereafter, it was ashed in a furnace at 600 °C for 2 h and allowed to cool down and weighed again (Irabor *et al.*, 2023).

The crude fibre of each of the samples analyzed was calculated using Equation (4)

$$\text{Crude fibre (\%)} = \frac{\text{weight of fibre}}{\text{weight of sample}} \times 100 \% \quad 4$$

where W_1 is the weight of empty crucible, W_2 is the weight of empty crucible + sample, and W_3 is the weight of empty crucible + ashed sample

Determination of crude fat of WBL

Ground WBL (2 g) ground powder was transferred onto a thimble. A small ball of cotton wool was placed into the thimble to prevent loss of the sample. An anti-bumping granule was added to a previously dried 250 mL flask and weighed accurately. A measured volume of 150 mL of Petroleum spirit was then added to the flask. A quick-fit condenser was connected to the Soxhlet extractor and refluxed for 4 h on a high heating mantle. The flask was removed and evaporated on a steam bath, after which it was heated for 30 min in an oven at a temperature of 103 °C. The flask and the content were later cooled to room temperature (25 °C) in a desiccator. Thereafter, they were weighed accurately so as to determine the weight of fat collected using the expression given in Equation 5 (Irabor *et al.*, 2023).

$$\% \text{ Crude Fat} = \frac{w_2 - w_3}{w_3 - w_1} \times 100 \% \quad 5$$

Where W_1 is the weight of the thimble, W_2 is the weight of the thimble + the sample, and W_3 is the weight of the defatted sample + the thimble (after drying).

Determination of Carbohydrate Percentage of WBL

The percentage carbohydrate of the sample was calculated using the relationship given in Equation (6).

$$\% \text{ Carbohydrate} = 100 - (\text{ash content} + \text{moisture} + \text{content crude} + \text{protein crude} + \text{fat crude} + \text{fibre}) \quad 6$$

Ultimate analysis

The ultimate analysis of WBL was carried out according to American Society for Testing and Materials (ASTM) standards D3174-76 for agro-waste. The percentage content of Carbon, Nitrogen, Hydrogen, Oxygen and sulphur in the WBL was determined in this section:

Determination of carbon and hydrogen percentage

The wet sample of the ground WBL were dried in oven for 10 minutes, thereby converting the carbon and hydrogen into carbon (iv) oxide (CO_2) and water (H_2O), respectively. The products of this combustion were passed over weighed tubes of anhydrous calcium chloride (CaCl_2) and potassium hydroxide (KOH), which absorb H_2O and CO_2 , respectively. The increase in weight of the CaCl_2 tube represents the weight of water (H_2O) formed, while the increase in the weight of KOH in the tube represents the weight of carbon (iv) oxide (CO_2) formed. % of Hydrogen (H) and Carbon (C) in the sample was calculated as expressed in Equations 7 and 8 (Yuang *et al.*, 2021).

Where X = weight of WBL, Y = increase in the weight of the CaCl_2 tube and Z = increase in the weight of the KOH tube.

$$\% \text{ of carbon in the sample} = \frac{12Z}{44X} \times 100 \% \quad 7$$

$$\% \text{ of hydrogen in the} = \frac{2Y}{18X} \times 100 \% \quad 8$$

Determination of nitrogen percentage

The Nitrogen in the WBL was determined by Kjeldahl's method. 1.00 g of the prepared sample of ground bamboo leaf was measured and recorded as W (g). The samples were heated with concentrated tetraoxosulphate (VI) acid (H_2SO_4) in the presence of Potassium tetraoxosulphate (VI) salt (K_2SO_4) and Copper (II) tetraoxosulphate (VI) salt (CuSO_4) in a long-necked flask called Kjeldahl's flask, thereby converting the nitrogen in the sample into ammonium sulphate. When a clear solution is obtained, all the nitrogen present is converted to ammonium sulphate, and the solution is treated with 50 % NaOH (Sodium hydroxide) solution (Yuang *et al.*, 2021).

The ammonia formed was distilled over and absorbed in a known quantity of standard H_2SO_4 solution. The volume of unused acid was then determined by titration against a standard solution of NaOH. The amount of acid neutralized by liberated NH_3 from the sample was then evaluated using Equation 9, while Equations 10 and 11 were used to determine the amount of nitrogen.

$$(\text{Titre Value}) V_t = V_1 - V_2 \text{ (cm}^3\text{)} \quad 9$$

where: V_1 = volume of H_2SO_4 neutralized (cm^3), V_2 = volume of H_2SO_4 neutralized in determination (cm^3), W_g = weight of the sample (g)

$$\% \text{ of Nitrogen Content in the solid Waste sample} = \frac{0.0014 \times 5 \times v_t}{W(g)} \times 100 \% \quad 10$$

$$\% \text{ Of Nitrogen Content in the sample} = \frac{\text{volume of acid used} \times \text{Normality}}{\text{weight of sample taken}} \times 1.4 \quad 11$$

Determination of sulphur percentage of WBL

Waste bamboo leaves (5 g) were digested and pipetted into 50 mL standard flasks, followed by 20 mL BaCl₂ solution and made up to the 50 mL mark. The solutions were allowed to stand for 30 minutes. The absorbance of the standard solution and the samples was read from the spectrophotometer at 420 nm. The graphs of absorbance against the concentration of standards were plotted and the sample concentration was evaluated from the graph. Equation 12 was used to calculate the % sulphur in the samples. The above procedures were repeated two times for each of the samples and the mean values were obtained (Pinto *et al.*, 2023).

$$\% \text{ of Sulphur in the sample} = \frac{R \times V \times D_f}{\text{weight of sample used}} \times 100 \% \quad 12$$

Where: R = Graph reading, V = Total Volume and D_f = Dilution factor

Determination of hydrogen and oxygen percentage in WBL

The percentage of hydrogen and oxygen in the sample was obtained indirectly by adding the percentage total carbon, nitrogen and sulphur together and subtracting from 100 according to Equations 13 and 14.

$$\% \text{ Hydrogen} = \frac{\text{Mass of hydrogen in sample}}{\text{Mass of dry sample}} \times 100 \quad 13$$

$$\% \text{ Oxygen} = 100 - (\%C + \%H + \%N + \%S) \quad 14$$

Where C, N and S represent Carbon, Nitrogen and Sulphur respectively.

Analytical characterization of WBL

This was done by using Scanning Electron Microscopy (SEM), X-ray Fluorescence (XRF) and X-ray Diffraction (XRD) for the determination of surface morphology, elemental components and crystallinity index, respectively, of the WBL.

Determination of the surface morphology of WBL

This was done using a Scanning Electron Microscopy (SEM/EDX) machine (SEM/EDX, Hitachi SU 3500 scanning microscope, Tokyo, Japan) machine (Pinto *et al.*, 2022). The WBL sample was made into a suspension of 0.01 % which was placed in the SEM machine at an accelerating voltage of 10 kv and 20 kV, while the magnification used was between 100 × (500 μm) and 1000 × (5 μm) (Pinto *et al.*, 2023).

Determination of the elemental component

This was carried out using X-ray Fluorescence machine Shimadzu EDXRF-702HS model to analyze the elemental composition of the WBL. All the measurements were carried out on an energy dispersive X-ray fluorescence spectrometer at 40 kV and 18 mA. The current was automatically adjusted. A 10 mm collimator was chosen and the counting was taken for 100 seconds for all measurements. The intensity of the element was obtained for the WBL. The sample was ground into fine particle size. The powder was pressed into a pellet to make it stable (Pinto *et al.*, 2023)

Determination of the Crystallinity Index (CI) of WBL

CI was used to determine the crystalline structure of the WBL. CI was carried out using X-ray Diffraction (XRD) spectrometer. Using XRD equipment at CuK^α radiation (λ=1.54183Å), 30 mA, 40 kV and 22 reflections, the samples were analyzed at 15-70 °C every 2 sec count time and 0.02° step size. The CI was calculated using Equation 15.

$$CI (\%) = \frac{I_{002} - I_{am}}{I_{am}} \times 100 \quad 15$$

Where I₀₀₂ is the maximum intensity of the 002 peaks and I_{am} is the minimal depression of the amorphous structure.

Ash Production

The ground WBL were calcined in a muffle furnace muffle (English Labscience SX-4-10 model) to obtain the ash yield and the silica content. Crucibles used were washed and dried in the oven for 30 mins to ensure total dryness and cooled in the desiccator for another 20 mins. The cooled crucibles were weighed on an analytical weighing balance and recorded as W_1 after which, 350 g of the ground WBL was put into the cooled crucible W_2 . The muffle furnace was heated up to 750 °C (Ojoawo *et al.*, 2025) The ashed WBL in the crucible was collected from the furnace after the set time 6 h (Ojoawo *et al.*, 2025) and cooled in the desiccator to room temperature before being weighed as W_3 . The samples were weighed and recorded as W_3 . The ash yield was calculated according to Equations 16 and 17.

$$\text{Ash yield (\%)} = \frac{\text{weight of ash}}{\text{weight of waste bamboo leave}} \times 100 \% \quad 16$$

$$= \frac{W_3 - W_1}{W_2 - W_1} \times 100 \% \quad 17$$

Where W_1 (g) is the weight of an empty crucible, W_2 (g) is the weight of the WBL and the empty crucible and W_3 (g) is the weight after the calcination process.

Results and Discussion

Proximate analysis

The moisture content, ash content, crude protein, crude fibre, crude fat and carbohydrate of the WBL were 2.88, 17.07, 5.44, 23.31, 0.64, and 50.65% respectively, as shown in Table 1. (Sareen 2025) deduced the ash content as 5.25% which was lower than the value obtained from this study (17.07 %), and carbohydrate as 34.20% which was lower than 50.65%. This variation may be due to different geographical locations or climate. The high percentage of ash shows that the WBL has a high amount of amorphous silica, which is beneficial for pozzolanic activity (Sahoo *et al.*, 2021).

Moisture content of WBL

The moisture content of the WBL was 2.88 %, which was in the range of 2 -3.7 % presented by (Dizbay-Onat 2023) for Activated Carbon Layer (ACL), which was less than 5.53 % obtained for rice husk (Samsalee *et al.*, 2023). (Yang *et al.*, 2024) carried out research on the impact of moisture on coal, and it was observed that the lower the moisture content, the higher the adsorption.

Percentage of Ash content

The ash content obtained for WBL in this study was 17.07 % which was higher than the 11.34 % obtained for WBL (Olawale *et al.*, 2021) and 5.25 % obtained by (Sareen 2025). This variation could be as a result of geographical variation.

Table 1: Proximate Analysis of WBL

Moisture Content (%)	Ash content (%)	Crude Protein (%)	Crude Fibre (%)	Crude fat (%)	Carbohydrate	References
10.36	11.34	15.23	32.37	1.11	55.60	[13]
4.51	5.25	18.22	27.20	1.43	34.20	[4]
2.88	17.07	5.44	23.31	0.64	50.65	This Study

Percentage of Crude protein

The value of crude protein obtained in this study was 5.44 % which was relatively lower than 15.23 % obtained for WBL by (Olawale *et al.*, 2021). The value of crude protein obtained shows that protein content is relatively moderate making it a potential nutrient source for animal feed (Sahoo *et al.*, 2021).

Percentage of Crude fibre

The value of crude fibre obtained in this study was 23.31 % which was relatively lower than 27.27 % obtained for wheat husk by (Sareen 2025). This indicates the occurrence of structurally intact cellulose that are resistant to degradation. This confirms their origin from vascular tissues (Sareen, 2025).

Percentage of Crude fat

The value of crude fat obtained in this study was 0.64 % which was lower than the value of 1.11 % obtained by (Olawale *et al.*, 2021) and lower than 1.43 % (Sareen, 2025). The low percentage of crude fat in the WBL may be less energy, which can affect its suitability for biofuel and anaerobic digestion. Its applications are the production of biogas such as methane, hydrogen and composting (Ibitoye *et al.*, 2023).

Percentage of Carbohydrate

The value of carbohydrate obtained in this study was 50.56 % which was relatively lower than 55.6 % obtained by (Yang *et al.*, 2024). This may be due to geographical variation. This implies that the WBL has energy potential. The WBL could be used in bioethanol, biogas, biochemicals production and animal feed.

Ultimate analysis

The percentage of carbon, hydrogen, nitrogen, sulphur and oxygen present in WBL were 49.25, 20.07, 2.32, 0.20 and 28.6 %, respectively as shown in Table 2. (Gautam *et al.*, 2024) reported carbon content of 35.95 % which was lower than 49.25 %, hydrogen of 5.14 % which was lower than 20.07 % and nitrogen of 1.35 % which was lower than 2.32 %. High carbon content indicates that the WBL can be a valuable source of energy through combustion / renewable energy source. High hydrogen content makes the WBL suitable for syngas production (Sahoo *et al.*, 2021).

Analytical characterization of the powder WBL

This was carried out by using SEM, XRD and XRF to determine the morphological formation, crystallinity and elemental composition respectively.

Surface morphology of the powder WBL

The surface morphology of raw powder WBL was examined by using Scanning Electron Microscopy (SEM) states relevant information about its functional nature, which is supported by the nutritional and phytochemical facts. Surface morphology of the powder is fibrous and irregular due to mechanical grinding process of mature bamboo leaves. The surface morphology of the powder bamboo leaves (BL) revealed fibrous and irregular shapes of the powder as shown in Figure 3. This was similar to SEM reported (Sareen and Sibian, 2025). The result was due to the mechanical grinding process of mature bamboo leaves (Sareen and Sibian, 2025). The irregular morphology of the WBL implies that it has surface roughness and this can influence the catalytic activity.

Table 2: Ultimate Analysis of raw WBL

	Carbon (%)	Hydrogen (%)	Nitrogen (%)	Sulphur (%)	Oxygen (%)	References
WBL	46.98	6.21	0.16	0.13	46.65	[9]
WBL	35.95	5.14	1.35	ND	57.56	[15]
WBL	49.25	20.07	2.32	0.20	28.16	This study

ND-Not Determined

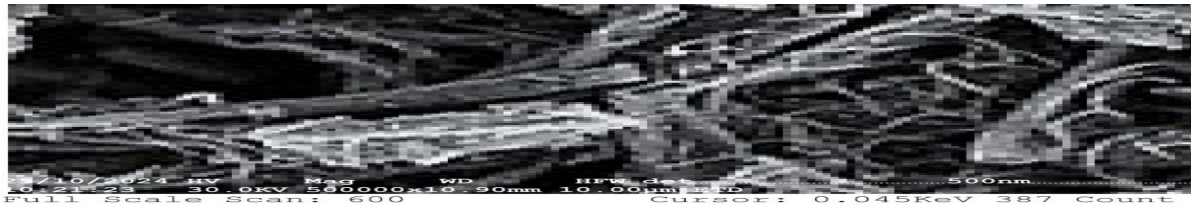


Figure 3:

SEM of powder WBL

Crystallinity index of the powder WBL

The CI of the WBL was analysed using XRD. This was done to be certain about the structure of the WBL. The diffractogram of the WBL is presented in Figure 4. The WBL has the following minerals calcium-oxalate, silica, Potassium Chloride, Cellulose crystal, Hemicellulose, Lignin, Potassium Carbonate and Magnesium Oxide with eight peaks at 2θ angles of 17.13, 26.46, 32.18, 34.25, 37.07, 41.35, 44.09 and 51.78⁰ at planes 101,100, 110, 300, 202, 211, 231 and 310 with 11.28, 19.15, 21.46, 52.63, 10.27, 13.54, 14.36 and 16.91 respectively a presented in Table 3. The highest peak at 2θ angles for WBL was 33.00⁰. The broad peak shows that the WBL was not crystallized and it contained amorphous silica (Olawale *et al.*, 2021).

Elemental composition of the powder WBL

The elemental composition of WBL was revealed by XRF. The component of the powder WBL (Table 4) SiO₂, Al₂O₃, with 60.42 %, 5.2 7%. The result reveals that the silica has the highest percentage, which would play a significant role in the synthesized zeolite (Olawale *et al.*, 2021).

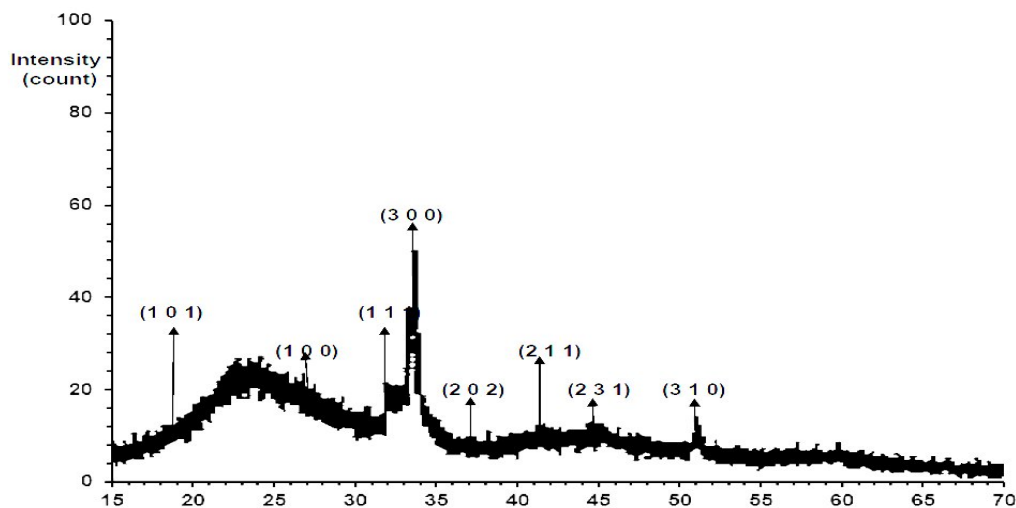


Figure 4: XRD spectra of WBL

Table 3: Analysis of XRD of powder WBL

Peak	2θ/degree	Plane	Intensity	d-Valve (Å)	Minerals	Compositions (Wt.%)
1	17.13	(1 0 1)	11.28	5.170	Calcium Oxalate	2.31
2	26.46	(1 0 0)	19.15	3.364	Silica	1.53
3	32.18	(1 1 1)	21.46	2.778	Potassium Chloride	0.26
4	34.25	(3 0 0)	52.63	2.615	Cellulose Crystal	49.48
5	37.07	(2 0 2)	10.27	2.422	Hemicellulose	14.25
6	41.35	(2 1 1)	13.54	2.181	Lignin	31.83

7	44.09	(2 3 1)	14.36	2.052	Potassium carbonate	0.16
8	51.78	(3 1 0)	16.91	1.763	Magnesium oxide	0.18

Table 4: XRF result of powder WBL

Basic Oxides	Formulae	%
Silicon oxide	SiO ₂	60.42
Aluminium oxide	Al ₂ O ₃	7.27
Magnesium Oxide	MgO	3.29
Calcium Oxide	CaO	8.97
Iron oxide	FeO ₂	0.25
Potassium oxide	K ₂ O	2.59
Sodium oxide	Na ₂ O	2.20
Phosphorus oxide	P ₂ O ₅	0.98
Titanium oxide	TiO ₂	0.08
Manganese oxide	MnO	0.05
Zinc oxide	ZnO	0.33
Copper oxide	CuO	0.02
Sulphate	SO ₃	0.15
Chromate oxide	Cr ₂ O ₅	0.01
LOI		9.40

LOI : Loss on Ignition

Characterisation of Waste Bamboo Leave Ash (WBLA)

The ash yield of WBL at 750 °C at 6 h was 25.0 %. The WBLA was characterised by XRF and the result obtained were as follows: SiO₂, Al₂O₃, K₂O, CaO, MgO, Fe₂O₃, Na₂O, P₂O₅, TiO₂, MnO, ZnO, CuO, SO₃, Cr₂O₅ and LOI of 67.34, 4.79, 2.03, 9.36, 3.22, 3.36, 3.01, 0.01, 0.40, 0.03, 0.30, 0.14, 0.01 and 5.97 respectively which could be further used for production of silica (Olawale *et al.*, 2021). The SiO₂ in raw WBL is lower than that of WBLA, this could be due to thermal decoposition and removal of hemicellulose, lignin and other organic matter shows that SiO₂ in WBLA is greater that the because most of the has been removed during calcination and concentrates inorganic minerals (Gautam *et al.*, 2023).

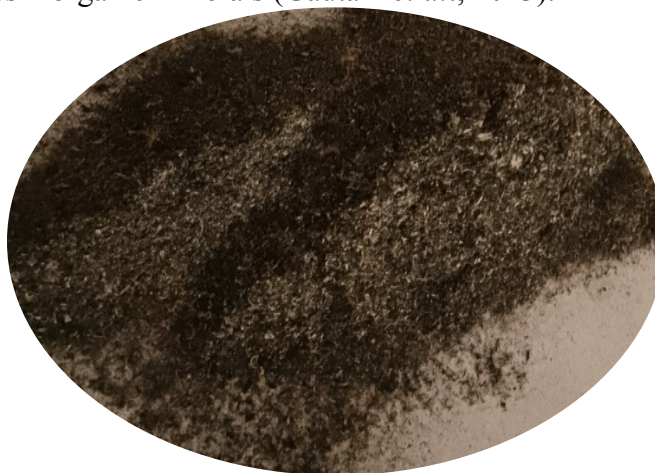


Plate 1: Pictorial view of WBLA

Conclusion

Bamboo is a rapidly growing plant that produces a substantial quantity of waste each year. Waste bamboo leaves (WBL) are commonly shed and may accumulate, thereby creating environmental concerns. In many

cases, these leaves are disposed of by open burning, which can contribute to air pollution. The findings of the study indicate that:

WBL is a useful and environmentally sustainable material. Its crude protein content suggests that it may serve as a potential nutrient source in animal feed production. The presence of crude fat also indicates its possible application in biogas generation. Furthermore, the carbon content of WBL demonstrates its potential as an alternative source of energy.

The chemical characterization also showed that WBL contains a high proportion of silicon dioxide (SiO_2). This property makes the material suitable for possible application in the synthesis zeolite which make it suitable for adsorption in wastewater treatment. This study contributes to sustainable material which help in reducing environmental pollution.

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