FUDMA Journal of Renewable and Atomic Energy (FJoRAE)
ISSN: 3027-2335
Vol. 1 No 1, March 2024. Pp 77-89

https://doi.org/10.33003/fjorae-2024-0101.07

MORPHOLOGICAL AND ELEMENTAL ANALYSIS OF SUGARCANE, BEANS AND RICE HUSKS ASH (SBRHA)

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Abstract

The morphological and elemental analysis of materials to assess their composition and suitability for various applications. Using agricultural crop wastes such as sugar cane back, rice husks, beans pod, as a partial replacement of sand in the manufacture of cement blocks, because they contain high calcium, silicon, aluminum, iron and other ingredients when control. The need to convert them into useful materials to minimize their negative effect on the environment. 100 g of untreated samples was measured in ratio 2:1:1 which is 50 g of sugar cane back, 25 g of beans pod and 25 g of rice husk. Sugarcane, beans and rice husks ash (SBRHA) as a silica source was structured, resulting from burning at a temperature of 550°C within 4:00 hours in an electric furnace. SBRHA consists of inorganic, combustible matter in the rice husk that has been fused into an amorphous structure. Microscopic techniques, such as x-ray diffraction (XRD), scanning electron microscopy (SEM) with (Energy Dispersion X-ray (EDX) were used to observe the surface and internal structure of the (SBRHA) the results among other things revealed that (SBRHA) consist of mainly Si, (61.43%), K (14.81%), Fe (1.41%), Al (2.05%) and Ca (5.59%) microscope examination showed that has a porous cellular structure and consists of irregular – shaped particles. This study has contributed to the advancement of scientific knowledge in the field of materials science, particularly in the utilization of biomass resources for innovative applications.

Keywords: Sugarcane, Beans, and Rice Husks Ash (SBRHA), Calcium, silicon, aluminium, Iron

1. Introduction

Because agricultural wastes are widely available and have the potential to be environmentally beneficial, their use as alternatives in construction materials has gained interest. The purpose of this study is to determine whether it is feasible to use rice husks, beans pods, and sugar cane back as partial sand substitutes in cement block manufacturing. These agricultural wastes are excellent prospects for sustainable material development since they are high in calcium, silicon, aluminum, iron, and other elements (Memon et al., 2011). In materials physics, analyzing a material's constituent elements to determine its composition and appropriateness for different uses is a common practice. Key elements and their amounts were determined by Onyelowe et al. (2021) by an elemental analysis of biomaterials such as velvet nut casings. Johar et al. (2012) and Onyelowe et al. (2019) conducted an investigation on the elemental composition of bean fibers and found that carbon, hydrogen, and oxygen were the most common main components. In materials physics, this constituent makeup is crucial, particularly for the creation of biodegradable materials with regulated qualities. In addition, studies conducted by Lee and Cutler (1975), Mehta (1992), and Chen et al. (2018) examined the silica concentration of rice hulls, which is a vital ingredient of industrial importance. In particular, their discoveries about using rice hulls as a sustainable supply of silica for advanced materials are relevant to materials physics. Because of their influence on environmental sustainability and their potential for sustainable uses, agricultural leftovers and waste materials have attracted more and more attention from scientists (Smith et al., 2001). These leftovers include sugarcane, bean husks, and rice husks, which are frequently produced in large amounts across the world. These materials have historically been thought of as agricultural waste, and the ways in which they have been disposed of—such as burning and dumping—have raised environmental issues (Basri et al., 1999; Azizi & Maryam, 2010; and Qu et al., 2022).

A large amount of the agricultural waste produced during the processing of sugarcane is made up of sugarcane shells. These shells have often been thrown away or utilized for low-value items like animal bedding. Nonetheless, scientists searching for sustainable materials for uses ranging from the generation of biofuel to agricultural supplements have been interested in them due to their chemical makeup and fibrous character (Awal et al., 1997). Garcia et al. (2018), Johnson et al., 2021). The byproduct of carefully managing the burning of sugarcane shells is sugarcane shell ash (SSA). The ash has a high silica content and lower levels of iron, aluminum, and alkali and alkaline earth oxides. The goal of this study is to partially substitute quartz in whiteware body compositions with this waste ash. The ash from sugarcane shells and other raw materials used to make the body formulations were subjected to chemical analysis (Fatile and Matthew, 2014). One of the most significant staple foods in the world is rice (Oryza sativa), especially in Asian nations. A sizable quantity of rice husks is produced as a byproduct of rice production. Rice husks have historically been burned or allowed to break down in rice fields, which increases methane emissions and air pollution. Yet, scientists have identified their potential as a source of important substances, including silica, and as a raw material for the generation of biomass energy (Yalcin, 2001; Yusof et al., 2010; Gebretatios et al., 2022).

These agricultural wastes are of importance for reasons more than just their fundamental chemical makeup. Scholars are progressively delving into their morphological and structural attributes, since they might offer valuable perspectives on their appropriateness for many uses (Kalapathy, et al., 2002). To maximize their application in sectors including agriculture, building, and materials science, it is important to comprehend the microscopic characteristics of sugarcane shells, bean husks, and rice husks (Chen et al., 2013; Jamo et al., 2014b and Islam et al., 2024). Moreover, the potential of these materials as sustainable substitutes is in line with international initiatives to cut waste, lessen environmental effect, and provide environmentally friendly solutions. In order to realize their full potential and add to the expanding body of knowledge in the fields of agricultural waste utilization and sustainable materials development, a thorough investigation into the morphological and elemental analysis of sugarcane shells, bean husks, and rice husks is necessary (Bhagiyalakshmi et al., 2010; Lee et al., 2017). By carefully analyzing these agricultural leftovers, our work aims to address these crucial issues and further our knowledge of their characteristics and their uses (Naskar & Chatterjee, 2004; Qu et al. 2022).

A paradigm change towards sustainability in all aspects of life has been brought about by the 21st century (Smith et al., 2001; Della et al., 2002). The research of agricultural residues has expanded into new areas because to developments in analytical methods and materials science (Smith et al., 2001, Yusof et al., 2010; Jamo et al 2014a,). An unparalleled degree of insight into the composition and structure of these materials is provided by contemporary spectroscopy, elemental analysis, and microscopy methods (Carty & Udayan, 1998; Prasad et al., 2001). Garcia et al. (2018); Chandara et al. (2012)). Current research frequently uses surface-level analytic approaches or concentrates on particular applications. A more comprehensive understanding of these materials' physical and chemical characteristics is required to fully realize their potential. From resource conservation to mitigating climate change, the need to minimize environmental footprints has taken center stage (Jamo et al., 2014b; Jamo, 2016; Nzereogu et al., 2023 and Islam et al., 2024). This makes the possibility for agricultural wastes like rice husks, bean husks, and sugarcane shells to function as sustainable resources even more appealing.

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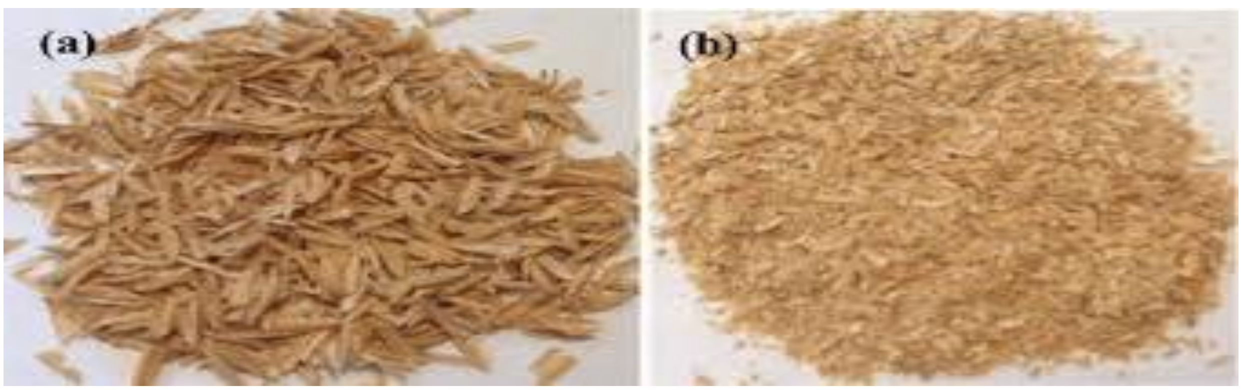
Nonetheless, the agricultural byproducts' potential worth has been reevaluated by enterprises and scholars due to recent trends toward sustainability, environmental conservation, and the circular economy.

2. Materials and Methods

2.1 Materials

Untreated samples of sugarcane shell, Beans husks and Rice husks were sourced from local agricultural markets in "Kasuwan Laraba Dutsin-Ma". Care was taken to select shells that were free from visible contaminants or damage. All the raw materials selected are abundant in Nigeria and they are currently being utilized for manufacturing different ceramic products (Onyelowe *et al.* 2019). Plate 1 presents the samples of the rice husks while Plate 2, presents the samples of the sugar cane and beans that were collected.



Rice husks

Plate 1: Pictures of Rice Samples Collected

(a) Sugarcane Shell (b) Beans Husk

Plate 2: Pictures of sugar cane and beans husks samples collected

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2.2 Method of sample preparation

The samples and procedures involved the acquisition of materials from the open market which were subsequently transported to the laboratory. These materials underwent a four-hour oven drying process at 100 ℃ each. Following this, the dried material was carefully removed from the oven and weighed. Subsequently, it was pulverized using mortar and pestle, then sieved and 100 g of samples were measured at 50 g, 25 g and 25 g which is thoroughly mixed 2:1:1 for sugar cane shell, beans pod and rice husk. After thorough mixture of the three samples. The sample were ashed in electric furnace for four hours at 550℃ and was allowed to cool before taking to laboratory for elemental and microscopy analysis. Plate 3 presents the ash sample.

Plate 3: Picture of Ash Samples

3. Results and Discussion

3.1 EDS Elemental Analysis

The Elemental Analysis this was done using Energy-Dispersive X-ray Spectroscopy (EDS) which verified the elemental makeup of the agricultural leftovers. Carbon, oxygen and hydrogen made up the majority of the sugarcane shell, with tiny quantities of other elements. The husk of beans showed a similar composition, with the main constituents being hydrogen, oxygen, and carbon. The composition of rice husk was unique, containing a large amount of silicon (Si) along with carbon, oxygen, and hydrogen. Figure 1 presents the elemental results of the EDXS.

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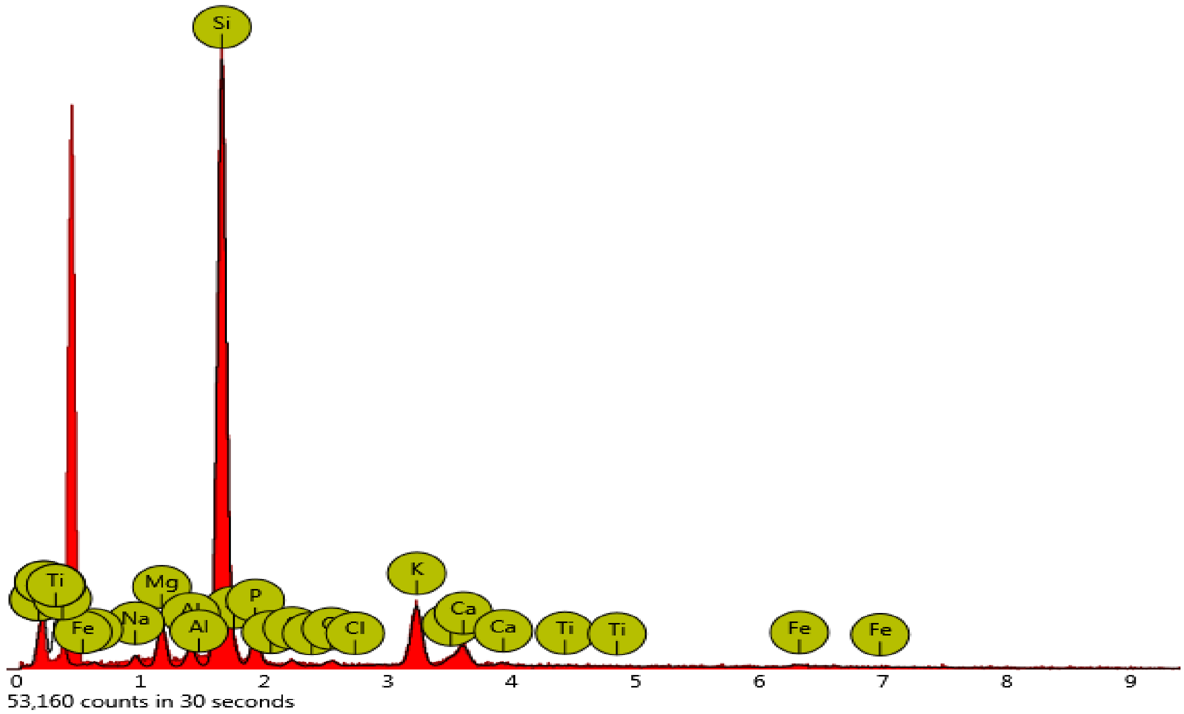

Figure 1: EDXS results of SBRHA

3.2 Scanning Electron Microscopy (SEM)

Plate 3, presents the picture of the Scanned Electron Microscopy of untreated SBRHA while Figure 2 presents the histogram of particle size in diameter (nm). According to the results, the image sample shows lignocellulose fibers that are visible, linked cells, and irregularly shaped cells with a fibrous and porous structure. Its surface seemed uneven and rough, which was in keeping with its inherent makeup. In addition to the material's distinct granular appearance due to the presence of silica bodies, SEM image also revealed that there was no SBRHA particle aggregation. SEM imaging gave precise information on the agricultural leftovers' microstructure. By fitting the particle distribution histogram with a log-normal distribution function, the estimated average particle size is 4.88966 nm, with a standard deviation of 3.14491 nm. The SEM pattern shows irregular dots interspersed with concentric clusters, suggesting that the current sample is rough.

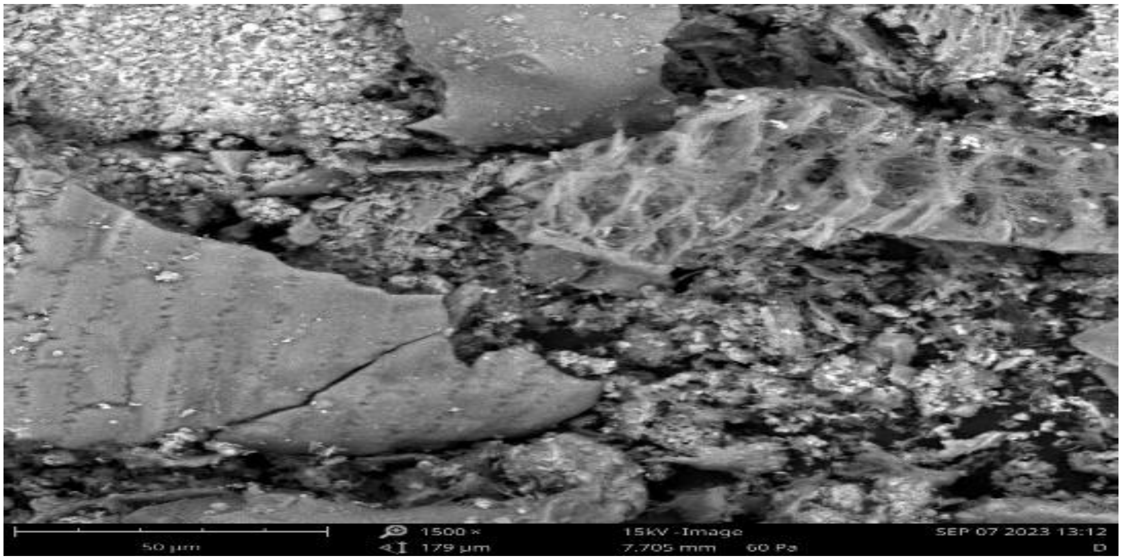

Plate 4: Scanned Electron Microscopy of untreated SBRHA

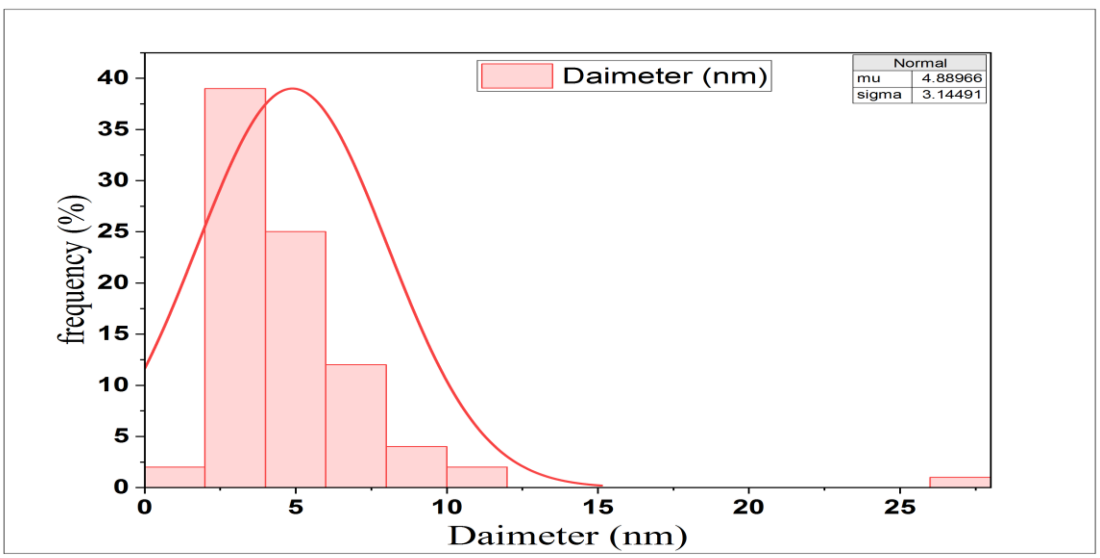

Figure 2: Particle size in diameter (nm)

3.3 X-Ray Fluorescence (XRF)

The elemental composition of the materials at the parts-per-million (ppm) level may be thoroughly examined by this approach. In addition to quantifying the elemental composition, XRF analysis also showed that the agricultural leftovers included trace elements. Bean husk and sugarcane shell showed comparable elemental profiles, with differences in trace elements. On the other hand, rice husk

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demonstrated a significantly increased silicon concentration, highlighting its potential as a silica source. Table 1 shows the atomic and weight concentration obtained through the XRF. From the table, the percentage of elemental weight concentration are; Silicon (SI) 61.43%, Potassium (K) 14.81%, Phosphorus P 6.56%, Calcium Ca 5.59%, Magnesium Mg 4.47%, Aluminum Al 2.05%, Iron Fe 1.41%, Sodium Na 1.19%, Sulfur S 1.17%, Chlorine Cl 1.04%, Titanium Ti 0.29% respectively. With Silicon being the highest and Titanium the least.

Table1: Atomic and weight concentration of XRF

Element Number	Element Symbol	Element Name	Atomic Conc. (%)	Weight Conc. (%)
14	Si	Silicon	65.77	61.43
19	K	Potassium	11.39	14.81
15	P	Phosphorus	6.37	6.56
20	Ca	Calcium	4.19	5.59
12	Mg	Magnesium	5.53	4.47
13	Al	Aluminum	2.28	2.05
26	Fe	Iron	0.76	1.41
11	Na	Sodium	1.55	1.19
16	S	Sulfur	1.09	1.17
17	Cl	Chlorine	0.88	1.04
22	Ti	Titanium	0.18	0.29

The microstructural characteristics of rice husk, beans husk, and sugarcane shell were identified by morphological examination. The fibrous and porous nature of sugarcane shell indicates that it can be used for agricultural amendments and the manufacture of biofuel. According to (Chindaprasirt *et al.*, 2007 and 2008), the fibrous matrix and birefringent qualities of bean husk indicate its potential in biodegradable composites and erosion management. The intricate microstructure and plentiful silica bodies of rice husks provide access to sophisticated materials with special qualities, such as adsorbents for environmental cleanup.

4. Conclusion

The study's conclusions have important ramifications for a number of disciplines, including environmental science, agriculture, and materials science. The elemental composition data sheds light on the potential uses of these agricultural leftovers, while the morphological qualities serve as a foundation for the construction of materials with specific properties. According to reports by Chapagain, Hoekstra, and others from 2005 and De Noni, Agenor, et al. (2010), sugarcane shell, bean husk, and rice husk may all be used as sustainable resources by enterprises looking for eco-friendly alternatives and solutions for the circular economy (Jamo et al., 2014b). The findings emphasize how crucial it is to take into account both morphological and elemental traits when evaluating agricultural leftovers' potential. These qualities can be used in future studies and applications to create novel, sustainable materials that support environmental preservation and resource conservation. The study's findings allow for the following conclusions to be made:

Diverse Microstructural Properties: The microstructural characteristics of sugarcane shell, bean husk, and rice husk are varied and unique, which makes them appropriate for a broad variety of applications in materials science and engineering.

Elemental Diversity: The statistics on elemental composition show that these agricultural leftovers have the potential to be sources of a wide range of elements, with silicon being particularly abundant in rice husk.

Circular economy and sustainability: These agricultural leftovers include morphological and elemental qualities that are consistent with circular economy ideas and sustainability principles, providing opportunity for resource- and eco-efficient uses.

Multidisciplinary Uses: The study highlights the multidisciplinary character of materials physics, where knowledge of microstructure and composition is essential to materials science. This study has contributed to the advancement of scientific knowledge in the field of materials science, particularly in the utilization of biomass resources for innovative applications.

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