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Production And Analysis of Potash from Sesame Seed Waste and Rice Husk

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ABSTRACT

The global demand for potassium-based fertilizers, such as potash, has surged due to its essential role in agriculture. This study explores the potential of agricultural waste, specifically sesame seed waste and rice husks, as sustainable sources for potash production. The aim of the research was to determine the percentage composition of compounds and elemental concentrations in both materials, using X-ray fluorescence (XRF) and Atomic Absorption Spectroscopy (AAS) techniques. Results revealed that rice husks contained 38.33% potassium oxide (K_2O), 17.26% calcium oxide (CaO), and 6.25% sulfur trioxide (SO_3), while sesame seed waste exhibited a higher potassium concentration of 58.04% K_2O. Elemental concentration analysis showed rice husks to contain 35.49 mg/kg potassium, and sesame seed waste had a notably higher concentration of 55.91 mg/kg potassium. Both materials demonstrated promising potassium content, positioning them as viable alternatives for potash production. The use of agricultural waste for potash extraction not only offers a sustainable solution for waste management but also provides an eco-friendly, cost-effective source for fertilizer production. These findings suggest that further developments in potash extraction techniques from these materials could significantly contribute to global agricultural and industrial needs.

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INTRODUCTION

The increasing global demand for food production has intensified the need for sustainable nutrient management strategies, particularly for potassium fertilizers, which are essential for plant growth, water regulation, enzyme activation, and improved crop productivity (Gahane & Mandavgane, 2024). Conventional potash production relies largely on mined mineral resources, creating concerns related to resource availability, environmental impacts, and dependence on imported fertilizer sources in many regions (Gahane & Mandavgane, 2024; Nguyen et al., 2024). The development of alternative potassium sources from agricultural residues has therefore gained attention as a component of circular agriculture and sustainable waste management systems (Gahane & Mandavgane, 2024; Nutrient Recovery Strategies and Agronomic Performance in Circular Farming, 2025).

Agricultural wastes such as rice husk and sesame seed residues are generated in large quantities and often experience disposal challenges, including open burning and accumulation, which can contribute to environmental pollution (Rouhani et al., 2024). However, these residues contain valuable mineral components, especially potassium, which can be recovered after controlled combustion and ash processing for fertilizer applications (Gahane & Mandavgane, 2024; Rouhani et al., 2024). Rice husk ash has been reported as a promising potassium-containing material that can improve soil nutrient availability and partially substitute conventional potassium fertilizers in agricultural systems (Padsuwan et al., 2024).

Potassium plays a critical role in crop performance by enhancing physiological processes such as photosynthesis, osmotic adjustment, nutrient transport, and stress tolerance (Wang et al., 2024). Studies on sesame cultivation have demonstrated that potassium supplementation can improve plant growth characteristics and reduce the negative effects of drought stress, highlighting the importance of sustainable potassium sources for crop production (Wang et al., 2024). Similarly, potassium recovery from agricultural and biomass wastes has been identified as an environmentally favourable approach because it reduces waste accumulation while contributing to nutrient recycling and fertilizer security (Gahane & Mandavgane, 2024).

MATERIALS AND METHODS

Materials

Whatman No 1 filter paper, volumetric flask, beakers, weighing balance, evaporating dish, hot plate, crucible, furnace, distilled water

Collection of Selected Sample

Dried samples of Sesame waste and rice husks were collected from Kalorgu, Kaltungo Local Government Area of Gombe state during dry season.

Sample Preparation

The collected sesame waste and rice husk were first crushed into finer particles to facilitate efficient combustion and analysis. Before ashing, the initial weights of the samples were recorded,

Ashing Process

The ashing process was conducted using a 1000ºC furnace, ensuring complete incineration of organic matter. After ashing the remaining residues were weighed with the rice husk ash recorded at 12.84 g and the sesame waste ash at 31.68 g, indicating variations in their mineral composition. Following the ashing, the residual ash was dissolved in distilled water to extract soluble mineral components. The solution was then filtered using pre-weighed filter paper to separate the dissolved mineral from any remaining undissolved residues. The filtration process involved weighing the crucible before and after ashing, weighing the sample within the crucible and filtering the dissolved ash solution through the pre-weighed filter paper. After filtration, the filter paper containing the undissolved residue was dried and weighed again to determine the amount of insoluble material present.

To recover the dissolved mineral content, the filtrate was transferred to pre-weighed evaporating dish and heated until all moisture was removed, leaving behind dry crystalline formations. The resulting crystals were collected and weighed, with the rice husk crystals recorded at 2.47 g and sesame waste crystals at 5.51 g

XRF Analysis

The X-ray fluorescence (XRF) analysis was carried out using a handheld energy-dispersive XRF spectrometer, following standard non-destructive testing protocols. Approximately 5 grams of dried, finely ground sample were placed into clean sample cups with a thin Mylar film base. The cups were tightly sealed to avoid contamination or spillage. The sample was then mounted securely on the XRF sample stage. Scanning was done for 60 to 120 seconds per sample, depending on the element of interest. The device provided direct readings of compounds percentage composition in mole%. The XRF software automatically adjusted for matrix effects based on pre-loaded algorithms.

Replicate measurements were considered for analytical reliability, and results were reported based on repeated instrumental readings to improve confidence in the reproducibility of the elemental analysis.

AAS Analysis

For the Elemental Analysis analysis, the samples were first filtered using Whatman filter paper to remove particulate matter. After filtration, a known volume of the sample was acidified with concentrated nitric acid (HNO_3) to adjust the pH to less than 2.0, which is necessary to prevent metal precipitation. The digest is then cooled, filtered, and brought to a final volume of 50 mL with de-ionized water. A calibration curve is created using aqueous standards ranging from 0.1 to 10 mg/L for each target element. A hollow-cathode lamp specific to each element is used, with the spectrometer set to the characteristic absorption wavelengths., The instrument is optimized for flame conditions with a fuel-to-oxidant ratio of 2:5 (acetylene to air). Samples are aspirated in triplicate, and background correction is applied using a deuterium lamp for non-specific absorption. Elemental concentrations are determined by comparing sample absorbances to the calibration curve, corrected for dilution. Results are reported in mg/kg. (Abdelmonem *et al.,* 2025.

RESULTS AND DISCUSSION

Results

Percentage composition of various compounds in rice husks

The percentage composition of various compounds in rice husks shows that K_2O (potassium oxide) is the most abundant compound, comprising 38.33% of the total moles. This is followed by CaO (calcium oxide) at 17.26% and SO_3 (sulfur trioxide) at 6.25% . Other significant compounds include SiO_2 (silicon dioxide) at 8.50% , P2O5 (phosphorus pentoxide) at 5.74% , and BaO (barium oxide) at 2.48% . The data indicates that rice husks are rich in potassium, which is crucial for potash production, and the presence of other compounds like calcium and sulfur also suggests potential for a variety of other applications, including agricultural uses.

When compared with other agricultural wastes such as plantain peels, cocoa pod husks, and corn stalks, which have been analyzed for their potash content, sesame waste and rice husks exhibit competitive or even superior potassium concentrations. Studies have shown that plantain peels contain K_2O concentrations of around 45-55% (Akinyele *et al.,* 2019), while cocoa pod husks range between 30-50% (Osei *et al.*, 2020).

Table .1: Percentage composition of various compounds in rice husks

COMPONENTS	MOLES %
SiO_2	8.500
MgO	0.134
P_2O_5	5.742
$S0_3$	6.250
CaO	17.261
K_2O	38.329
BaO	2.484
Ta_2O_5	0.424
Ag_2O	4.356
$Zr0_2$	1.174
Rb_20	0.150

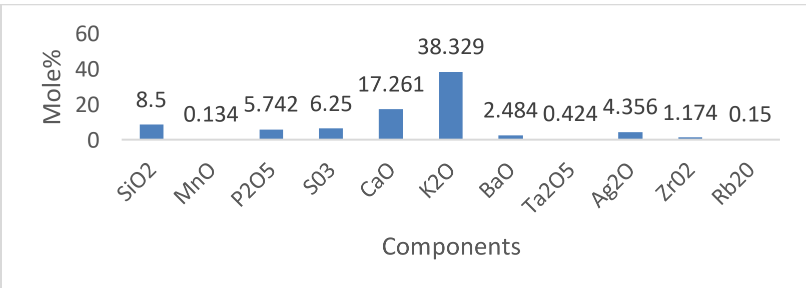

Figure 1: Percentage composition of various compounds in rice husks

Concentrations of Elements in Rice Husks

In terms of elemental concentration, potassium (K) is the dominant element in rice husks, constituting 35.49 mg/kg of the material. Oxygen (O) is the second most abundant element at 34.46 mg/kg, followed by magnesium (Mg) at 4.97 mg/kg and silicon (Si) at 2.83 mg/kg. Phosphorus (P) makes up 10.80 mg/kg, while calcium (Ca) is present at 2.97 mg/kg. Other elements in trace amounts include iron (Fe) at 0.46 mg/kg and rubidium (Rb) at 0.30 mg/kg. These values demonstrate a good concentration of elements that are beneficial for both potash extraction and potential agricultural or industrial uses. The potassium content aligns well with findings from Nouri *et al.* (2022), who reported a potassium concentration of approximately 36 mg/kg in rice husks.

Table 2: Concentrations of elements in rice husks

ELEMENT	CONCENTRATION (mg/kg)
O	34.455
Mg	4.968
Al	1.590
Si	2.827
P	10.803
Sa	2.18
Cl	1.829
K	35.492
Ca	2.966
Ti	0.240
Fe	0.459
Rb	0.303

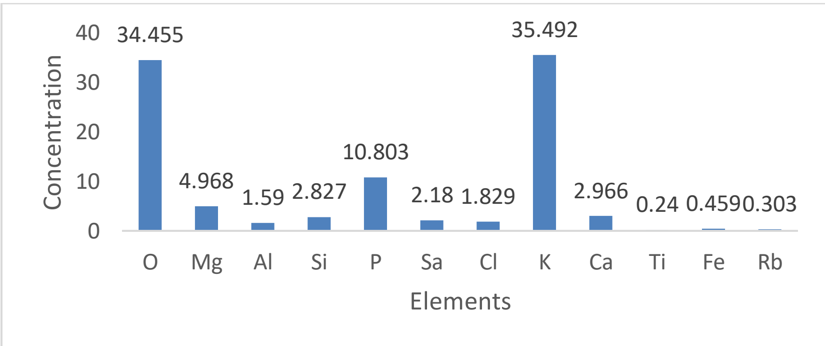

Figure 2: Concentration of elements in rice husks

Percentage Composition of Various Compounds in Sesame Seed Waste

The percentage composition of various compounds in sesame seed waste reveals that K2O (potassium oxide) is the most abundant compound, comprising 58.04% of the total moles. This is followed by SO3 (sulfur trioxide) at 11.62% and MgO (magnesium oxide) at 15.95%. Other compounds include SiO2 (silicon dioxide) at 2.62%, Fe2O3 (iron oxide) at 0.16%, and CaO (calcium oxide) at 0.55%, with smaller amounts of TiO2 (titanium dioxide) at 0.36%. The high percentage of potassium oxide suggests that sesame seed waste is an excellent source of potassium, which is crucial for producing potash, and the other compounds can potentially provide additional benefits for various industrial or agricultural processes.

When compared with other agricultural wastes such as plantain peels, cocoa pod husks, and corn stalks, which have been analyzed for their potash content, sesame waste and rice husks exhibit competitive or even superior potassium concentrations. Studies have shown that plantain peels contain K_2O concentrations of around 45-55% (Akinyele *et al.*, 2019),

Table 3: Percentage Composition of Various Compounds in Sesame Seed Waste

COMPONENTS	MOLES%
SiO_2	2.624
Fe_2O_3	0.164
SO_3	11.621
CaO	0.554
MgO	15.945
K_2O	58.040
Al_2O_5	3.732
TiO_2	0.356

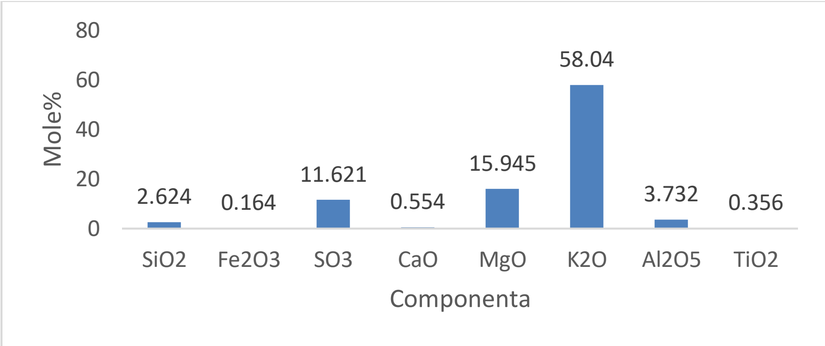

Figure 3: Percentage composition of various compounds in sesame seed waste

Concentrations of Elements in Sesame Seed Waste

In terms of elemental concentration, potassium (K) dominates with 55.91 mg/kg , followed by oxygen (O) at 25.7 mg/kg and sulfur (S) at 4.59% . Magnesium (Mg) is present at 4.77 mg/kg , and calcium (Ca) at 0.27% , while iron (Fe) is found at 0.23 mg/kg and rubidium (Rb) at 0.11 mg/kg . Minor elements like tin (Sn) are also present at 2.35 mg.kg . These results confirm sesame seed waste as a rich source of potassium, reinforcing findings from Nouri *et al*. (2022) , who recorded 55.5 mg/kg potassium in sesame seed waste. This makes sesame seed waste a valuable raw material for potash production and other potential applications.

Table .4: Percentage Composition of Elements in Sesame Seed Waste

ELEMENT	CONCENTRATION (mg/kg)
O	25.776
Mg	4.774
Al	2.480
Si	0.908
S	4.590
Cl	2.243
K	55.907
Ca	0.273
Ti	0.210
Fe	0.226
Rb	0.107
Sn	2.350

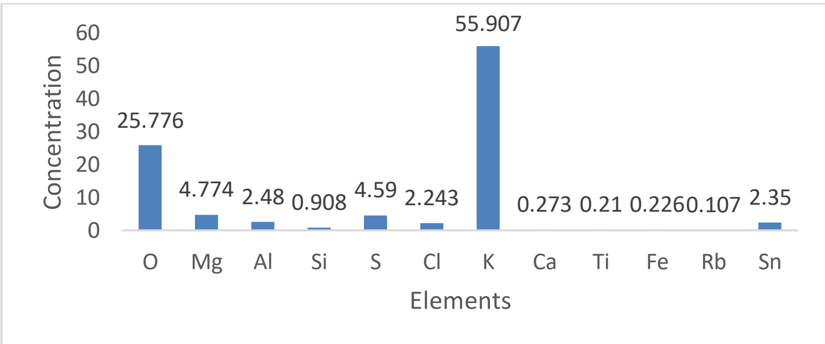

Figure 4: Concentration of elements in sesame seed waste

Additional discussion on potassium variation:

The higher potassium content observed in sesame seed waste compared with rice husk may be associated with differences in plant physiology, mineral uptake, ash-forming constituents, and the distribution of inorganic nutrients within the plant tissues. Sesame residues contain a higher proportion of mineral components that remain concentrated after combustion, which may explain the greater K_2O composition detected by XRF analysis. Similar investigations published in FUDMA Journal of Sciences have demonstrated that agricultural residues can contain valuable mineral constituents and that XRF analysis is useful for evaluating elemental and compound composition of biomass-derived materials (Adamu et al., 2023). Therefore, variation in potassium content among agricultural wastes is expected and depends on crop type, cultivation conditions, and processing history.

CONCLUSION

The analysis of sesame waste and rice husks demonstrates that both are effective sources of potash, with sesame husks exhibiting the highest potassium concentration. Their high K_2O mole percentage confirms their potential as sustainable alternatives to traditional potash sources. Utilizing these agricultural wastes for potash extraction supports environmental sustainability, reduces waste accumulation, and provides economic benefits. Additionally, the versatility of potash in multiple industries ensures its continued relevance, making the study of agricultural waste-derived potash crucial for long-term sustainability. Future advancements in potash extraction and processing could further enhance efficiency and cost-effectiveness, contributing significantly to global agricultural and industrial needs.

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