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Influence of Heat of Combustion on the Physicochemical Properties of Rice-bran Obtained from Mubi, Adamawa State, Nigeria

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ABSTRACT

Rice bran, one of the most abundant and valuable byproducts produced during the rice milling process, is of steadily growing interest in recent years due to its potential health benefits. Herein, we investigate and report the physicochemical properties of rice bran obtained from Mubi, Adamawa State, Nigeria. The rice bran was initially combusted and soil samples of the baked, unbaked soil and surrounding particular area where we carried out the combustion were collected and analyzed for its physicochemical properties. The results revealed that the baked soil has a higher concentration of calcium, magnesium, potassium and sodium than the unbaked soil. Furthermore, retention of water (tension) and the ability to absorb water (infiltration) was discovered to be higher in the baked soil sample. This shows that the heat of combustion of rice bran affects the physical, chemical and mechanical properties of soil in a peculiar way.

1 Introduction

Rice (*Oryzae sativa*, Family: Oryzeae) is a major cereal crop around the globe. About half of the world's population consumes rice as dietary staple. It is second most grown food crop globally after wheat. Rice is grown in approximately 114 countries which produce more than 650 million tons annually [1]. In terms of per capita energy, human are gaining 23% energy globally from rice [1]. Rice-bran is a by-product produced during the process of milling. The bran constitutes nearly 7-8.5% of the total grain. The bran consists of the pericarp, tegmen (the layer covering the endosperm), aleurone, and sub-aleurone [1, 2]. Due to the growing concern of environmental pollution and an increasing interest in conservation of energy and resources, the traditional heap out disposal of rice bran (about 120 million tones in developing countries alone) is no longer acceptable as environment-friendly [3]. Conversion of the rice bran is an appropriate form of disposal and an encouraging technology that has brought benefits to producers in Asia and Latin America and is hope to benefit the small-scale farmers, rice millers and the environment in Nigeria [3]. Rice bran is generated as an agricultural (organic) waste from milled paddy grain. On combusting rice bran, rice bran ash, a bioenergy residue is obtained. Rice bran is burnt at a controlled temperature using various methods to yield white or grey colored ash (called rice bran ash). The global production of paddy rice in 2014 was over 738 million metric tons (MMT), which provides approximately 70 MMT of bran [4]. However, rice bran possesses important components such as proteins and phytochemicals that supply beneficial health effects on the human body; it is mainly used for animal feed. Being high in protein, particularly the essential amino acid lysine, soluble and insoluble dietary fiber, it exhibits high nutritional value for human consumption [3]. Thus, these properties are considered a healthy functional food, which has hypoallergenic, hypocholesterolemic and antioxidative properties [5]. Indeed, the health effects of rice bran have encouraged many researchers to study its ability to be used as an important source of nutrients in food ingredients [6-8].

A moisture absorbing material can be formed by burning rice bran at high temperatures of about 700 and 2100 degrees Fahrenheit hence, it is sterile. Thus, when placed in the ground for plants, it inhibits or prevents the growth of aerobic and anaerobic bacteria (such as mold and mildew) which normally disturbs growth patterns in some soils. Most importantly, it will not contaminate food from plants grown in such soils. The theory behind the absorptive capacity of this burnt rice bran product is that, during the pressure parboiling, drying and high temperature burning of rice bran to create a residue of amorphous silicate, the materials is formed with many chambers or cells vacated by cellulose and expanded by heating. Each minute (small) cell opening allows a variety of liquids of a wide range of viscosity to flow into, thereby displacing air from the cells or chambers. These cells are non-selective in absorption of multiphase liquids. However, the liquid of least viscosity would usually be absorbed first. When the chambers are filled, they have a tendency to retain the liquid because of surface tension of the

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liquids in their static state. Furthermore, due to equalizing flow through holes in each chamber, all the chambers tend to reach a state of equilibrium; therefore this material is capable of absorbing liquids of almost 100% of its own volume. Apart from informing of the availability of rice bran ash technology and its products and benefits, this study intends to focus on the effect of heat of combustion of rice bran on arid soil, as a means of providing an alternative for the safe disposal of rice bran instead of the traditional heap out method.

2 Materials and Methodology

2.1 Sample Collection

Rice bran was obtained from a rice milling plant and was combusted on arid soil. After burning, samples of the baked soil, the burnt ash and the unburnt soil surrounding the area where the burning took place were all collected and taken to the laboratory for the determination of some physical, chemical and mechanical parameters.

2.2 Preparation of Soil Digestion (Aqua Regia) Samples by Wet Digestion

2 grams of dry soil samples was weighed in an electronic weighing balance. It was transferred to a $50cm^3$ Kjedhal flask. To the flask, $5cm^3$ of $HN0_3$ followed by lcm^3 of HCI was added to the content of the flask. The solution was stirred and heated on an electro thermal mantle until white fumes formed during heating, disappeared. The content of the flask was allowed to cool and was transferred quantitatively in to a $50cm^3$ volumteric flask. It was diluted and made up to mark with distilled water. The solution was mixed thoroughly filtered and then stored in plastic containers for flame photometry.

2.3 Elemental Analysis

The physical parameters determined include soil pH conductimetry, and relative density. The chemical parameters, analyzed were calcium and magnesium using EDTA complexiometric titration method, potassium and sodium were determined using flame photometry respectively. Infiltration and water retention capacity were the mechanical parameters determined, using a double ring infiltrometer and tension meter respectively.

3. Results and Discussion

It is important to recall that this work is aimed at investigating how the combustion of rice bran on arid soil affects the physical, chemical and mechanical properties of soil. The unburnt soil samples were notated UBS 1-5, the baked soil sample were assigned the notation BBS 1-5 and a mixture of baked soil and rice bran ash (2:1) were labeled BAS 1-5. The results of physical parameter analyzed are given below in Table 1.

3.1 pH

The pH for soil samples BBS (baked soil samples) were high, that of sample BAS (mixture of baked soil and rice bran in the ratio 2: 1) were even higher compared to the lower pH values exhibited by sample UBS (unburnt soil samples).

High pH values obtained in samples BBS and BAS indicate that the soils are alkaline compared to the weak acidity exhibited in samples UBS. Aluminum and hydrogen ion in soil could be responsible for the weak acidity in soil sample UBS. Chemical equation can be used to validate this claim.

$$Al^{3+} + OH \rightarrow 3AlOH_2 + OH$$

Table 1. Physical parameters of soil samples analyzed.

Sample code	Colour sample	Standard notation	Relative density	PH	Conductivity
USB 1	Reddish brown	2.5 YR4/3	2.15	6.0	0.060
USB2	Reddish brown	2.5 YR4/3	2.15	6.2	0.058
USB3	Reddish brown	2.5 YR4/3	2.15	6.2	0.056
USB4	Reddish brown	2.5 YR4/3	2.15	6.2	0.056
USB5	Reddish brown	2.5 YR4/3	2.15	6.2	0.056
MEAN					
BBS1	Gray	7YR4./2	1.14	8.2	0.180
BBS2	Gray	7YR4./2	1.14	8.0	0177
BSS3	Gray	7YR4./2	1.14	8.4	0.180
BBS4	Gray	7YR4./2	1.14	8.2	0.173
BBS5	Gray	7YR4./2	1.14	8.2	0.175
Mean std					
BAS 1	Very dark gray	7.5YR3./1	1.31	9.5	0.170
BAS 2	Very dark gray	7.5YR3./1	1.31	9.8	0.170
BAS 3	Very dark gray	7.5YR3./1	1.31	9.8	0.170
BAS 4	very dark gray	7.5YR3./1	1.31	9.8	0.170
BAS 5	Very dark gray	7.5YR3./1	1.31	9.8	0.170

Table 2. Chemical parameters analyzed in soil sample.

Sample code	Ca (Mg)	Mg (mg)	Na (%)	K(q)
USB 1	0.80	0.53	0.7	0.1
USB 2	1.00	0.43	0.7	0.1
USB 3	1.00	0.43	0.7	0.1
USB 4	1.00	0.43	0.7	0.1
USB 5	0.80	0.43	0.7	0.1
Mean				
BBS 1	2.40	0.72	1.15	0.20
BBS 2	2.40	0.72	1.15	0.20
BBS 3	2.40	0.72	1.35	0.32
BBS 4	2.40	0.72	1.15	0.32
BBS 5	2.40	0.72	1.15	0.44
Mean std				
BAS 1	3.00	1.09	3.45	0.92
BAS 2	3.00	1.09	3.00	1.00
BAS 3	3.00	1.09	3.00	0.92
BAS 4	3.00	1.09	3.00	0.92
BAS 5	3.00	1.09	3.00	1.00

Much of the aluminum hydroxide ions are adsorbed and act as exchangeable cations. They are in equilibrium with similar cations in the soil solution, where they produce hydrogen ions by hydrolysis.

3.2 Conductivity

The result for conductivity shows that samples BBS and BAS have higher conductivity value than soil samples UBS possibly because they have a higher concentration of conducting ions.

3.3 Chemical Parameters

The results of the analysis showed that the values of the macro nutrients, potassium, magnesium and calcium and that of the essential element, sodium exist in higher quantities for sample BBS and BAS. My hypothesis is that since these elements exist in the form of chelates and organomineral complexes in the soil, the heat of combustion from the rice bran must have brought about the rupture, and disintegration of these compounds into their ionic forms thereby making them available in a more soluble form. This claim was validated in Mubi, Adamawa state where some species of cultivars were cultivated in a garden where rice bran has been burnt prior to planting. The same species of crops were also cultivated on areas where rice bran was not burnt, on the same piece of land. After several months, the crops on the area where rice ban was burnt were found to have grown bigger and taller than the rest of the crop. In addition to this, weeds were also completely controlled.

3.4 Mechanical Parameters

The values obtained from infiltration and water retention analysis revealed that soil samples burnt with rice bran has a higher capacity to hold and retain water. This is a desirable quality of soils which are to be used for agricultural purposes. The slow absorption of water as shown by the unburnt soil samples could result in erosion and possible leaching of essential element from the soil

4. Conclusion

From the results obtained from this project work, one can conclude that combusting rice bran on the soil is a better method of disposing this agricultural waste product rather than the traditional heap out method, which according to stakeholders in environmental regulation, could result in environmental pollution problems. One can also conclude from the pH value obtained that rice bran ash can alleviate soil acidity by binding the major ions responsible for acidity(A13+ and H+) to nontoxic complexes, thereby reducing -the effects of soil acidity. Rice bran ash, according to literature has the capability of retaining moisture in its pores and releasing it slowly to plants especially during the dry season.

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