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ASSESSMENT OF FERTILIZER QUALITY OF FRESH AND DIGESTED CEREAL STRAW CODIGESTED WITH COW DUNG FOR BIOGAS PRODUCTION

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Abstract

In this paper, laboratory analyses of cow dung and pretreated and optimized straws of maize, sorghum, millet with cowdung were assessed and compared for their ash and nutrient content before and after anaerobic digestion. These comparison where also on the basis of their proportion of Nitrogen (N), Phosphorus (P), Potassium (K) content before and after anaerobic digestion. Standard methods were used for detecting their ash and N,P,K content.Results of the analysis on the difference in Ash contents between the fresh and digested biomass shows an increase of 38%, 43%, 38% and 36% in Cow dung (Control), Sorghum + Cow dung (**MD_1**), Maize + Cow dung (**MD_2**) and Millet + Cow dung (**MD_3**) respectively; the order being : **MD_1> MD_2 > Control (C) > MD_3.**While the overall trend in N, P, K content after the experiment is MD_1> **MD_2> Control > MD_3**. This order suggests that **MD_1**containedthe highest mineral elements or plants macro and micro nutrients such as Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Manganese (Mn), Zinc (Zn), Copper (Cu) etc. while **MD_3**contained the least of these elements. Therefore, MD_1 can be concluded as the one with the best fertilizer quality. This study also identified that, the ash contents of all biomass increased to about 40% on average a after anaerobic digestions.This implies that, the digested biomass has better fertilizing effect, because the mineral or inorganic content of biomass is reflected in its ash content. The more the ash content the higher the mineral contents (**N, P, K,** etc.) and by implication the better the fertilizer quality of the substrate.

Keywords: Fertilizer Quality, Cereal Crop's Straws, Cow Dung

1.0. Introduction

A bio-slurry or Compost is produced from anaerobic digestion of organic materials particularly during biogas production. Biogas digester can be filled with locally-available raw materials such as; crop residues, animal waste (pig, poultry, and cattle) and human waste such as urine and dung. *'During digestion, about 25-30% of the total dry matter (total solids content of fresh dung) of animal/human wastes will be converted into a combustible gas and a residue of 70-75% of the total solids content of the fresh dung comes out as sludge which is known as digested slurry or biogas slurry*(SNV, 2011a). With the right amounts of materials, the composition of the bio-slurry can consist of 93% water and 7% dry matter, of which 4.5% is organic matter and 2.5% inorganic matter (Staff of National Bio-digester Program, 2015).

Bioslurry contains mineral and organic dry matter which are readily-available plant nutrients (N, P, K, Ca, Mg, Mn,) different amino acids and metals (zinc, iron, manganese and copper)(Igboro 2010). The last of which has become a limited factor in many soils(Gurung, 1998). Bioslurry contains higher amounts of these nutrients and micro nutrients than farmyard manure (FYM) and composted manure(Gurung, 1998). It can increase cereal crop productions by 10 to 30% compared to ordinary manure(Gurung, 1998). The composition of bioslurry depends upon several factors: the dung source (animal, human, or other feedstock), water, breeds and ages of the animals, types of feed and feeding rates(Centre for Energy Studies, 2001).

Bioslurry can be used to fertilize crops directly or added to composting of other organic materials. Bioslurry is an already-digested source of animal waste because during digestion nutrients are transformed from organic states to dissolved states, making them more useful for plant uptake(Lansing *et al*., 2010)and if urine (animal and/or human) is added, more nitrogen is added to the bioslurry which can speed up the compost-making process. This improves the carbon/nitrogen (C/N) ratio in the compost(C. E. S. I. E. 2001). However, the quality of the produced bio-slurry is determined by the digester design.

Biogas and bio-slurry offer several benefits by improving fertiliser qualities, reducing odours and pathogens and providing renewable energy and fuel(Holm *et al* (2009). The use of bio-slurry on farm; provides slow release of plant nutrients in the soil which is better for nutrient uptake and assimilation for plants, low in Carbon/anaerobic Nitrogen ratio, will cause quick mineralization of soil organic matter, increases nutritional content in plants, it prevent plant diseases, avert run-off and retained moisture content in soil, build healthy fertile soil for crop production and produced testier fruits and vegetables. Chemical Fertilizers provide short term results yet in long term damage the soil by interfering with its pH, modified the kinds of microorganism that provide plants with natural immunity against diseases(Certified Organic OMRI Fertilizer, 2015), undermined ground water, and more importantly our health. Because, excessive air and water borne nitrogen from fertilizer may cause: respiratory ailments, cardiac disease cancers and methemoglobinemia (AgriHunt For Agricultural Knowledge, 2014).

This paper aims to determine the fertilizer quality of fresh and digested cereal straw co-digested with cow dung for biogas production. This was done by conducting a laboratory analysis on *Ash content* and the vital plant nutrient encompasses *Nitrogen (N), Phosphorus* (P_2O_5) *and Potassium* (K_2O)of each biomass resources both before and after anaerobic digestion and the result was compared to know the extent of conversion of each substrate.

2.0. Material and Method

2.1. Description of the Study Area

The experiment was carried out at the Sanitary Chemistry and Microbiology Laboratory of the Department of Water Resources and Environmental Engineering, Faculty of Engineering, Ahmadu Bello University, Zaria. Locatedon latitude $11^0 9^1 5.94^{11}$N and longitude $7^0 38^1 5.17^{11}$E At the North-Western part of Nigeria.

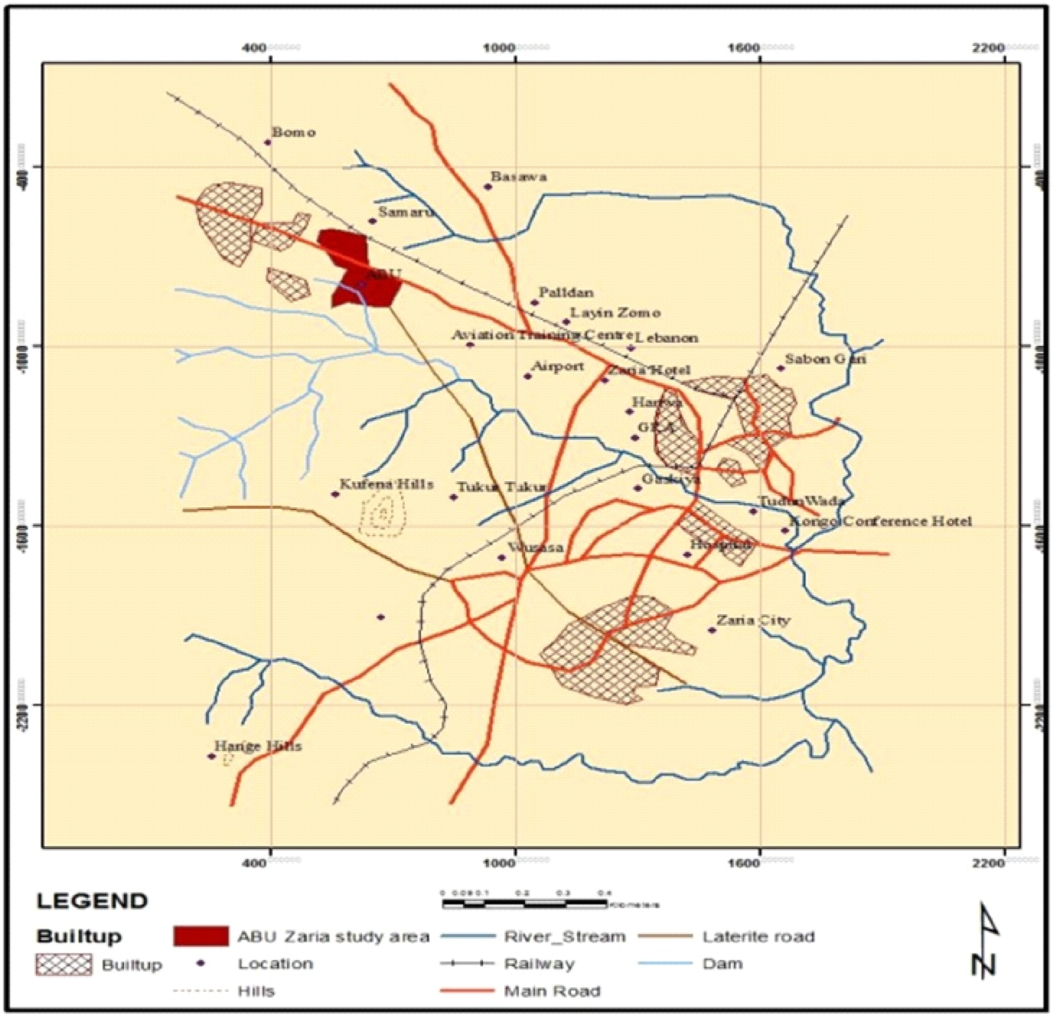

Figure 1: The Study Area(Source; Idowo and Yetunde 2012).

2.2. Instruments/Apparatus and Chemical Used

Chemicals of analar grade were used in the preparation of solutions as well as routine laboratory analyses using equipment such as; 6100 Spectrophotometer, Flame Photometer, Ohaus-Brain weigh Moisture Determination equipment, Furnace (0-1200^{o}C), 19 Litre dispenser rubber as digester, Oven (0-200^{o}C), Kjeldahl apparatus, Analytical Mill and Hanna Pocket-Sized pH meter and glass wares.

2.3. Raw materials

Dried Cereal straws from maize, millet, sorghum and fresh cattle manure sourced from Samaru College of Agriculture, Division of Agricultural College, Ahmadu Bello University, Zaria.

3.0. Method

3.1. Optimization of Cereal Straw with Inoculums (Cow dung)

On the average plant material like cereal straw of agricultural waste have a carbon to nitrogen (C/N) ratio of about 60:1 as against the ratio of 20:1 or 30:1 for maximum proliferation of the bacteria in the degradation process of anaerobic digestion to produce biogas (Braun, 1982).Therefore 30g of cereal straw was mixed with 1kg of cow dung to optimize the cereal straw.

For 1kg of cow dung, the corn straw that should be mixed was calculated below;

Recommended Carbon to Nitrogen $\left(\frac{C}{N}\right)$ratio is 25 $\left\{\text{average i. e.} \left(\frac{20+30}{2}\right)\right\}$

$$\therefore 1[\text{kg}]\times 24\left\{\left(\frac{C}{N}\right)\right\} + R[\text{kg}] \times 60[\left\{\left(\frac{C}{N}\right)\right\} = (1+R)[\text{kg}] \times 25\left\{\left(\frac{C}{N}\right)\right\} \quad (1)$$

Where; R is the weight of corn straw in kg, N is the nitrogen and C is the carbon

Therefore, $R = \frac{1}{35}$ = 0.029kg= 29g and R to the nearest tenth is 30g . (Therefore, for each k g of Cow dung 0.030kg (30g) of cereal straw should be mixed).

3.2. Pretreatmentof the raw material and experimental pattern

The straws were milled by using a grinding machine to a size of 1.0 - 2.0 mm and subjected to a thermal pretreatment by mixing the ground biomass with water at a temperature of 100°C for 1 hour. The pretreatment step was done in order to depolymerise the lignocellulosic complex and increase the rate of degradation and the biogas potential of the substrates(Sasse*et al*., 1991).

3.3. Preparation of the Samples

After pretreatment180g of each pretreated Agricultural waste i.e. maize, millet and sorghum straws was mixed with 6kg and 7 litre of Cow dung and water respectively. Then the final mixture was then slurried to obtain 8% dry weight in all batches(Ituen*et al*., 2007), (Akpan1995), and put into an air tied digester for anaerobic digestion to takes place for 40 days. However, 6kg of Cow dung only(Control) was mixed with 6litre of water in ratio 1:1 by volume that is one part of waste and one part of water and follows same procedure as discussed above. Some pretreated and mixed biomass was taken to the laboratory for proximate analysis. The Micro-digester used in this research consisted of four 19 litre polycarbonate plastic water dispenser rubber.

3.4. Laboratory Analysis

3.4.1. Determination of Ash content (AC)

The standard method for ash content as described by Zuruet al, (2001) and briefly highlighted below was used.

$$\% \text{ AC} = \frac{m_4 - m_0}{m_3 - m_0} \times 100 \quad (2)$$

m_0= mass of empty crucible;
m_3= Mass of dried sample and dried cruciblebefore heated in a muffle furnace;
m_4 = Mass of dried sample and dried crucible after heated in a muffle furnace.

3.4.2. Determination of Nitrogen

The micro Kjeldahl method as described by Uriyo and Singh, (1974) was used to determine the nitrogen content in the samples.

3.4.3. Determination of Phosphorus

The phosphorus content of the substrates was determined using the colorimetric method based on formation of an ammonium molybdate complex as described by Uriyo and Singh, (1974).

3.4.4. Determination of Potassium

The potassium content of the substrates was determined using emission technique. The principle of the technique is described by Uriyo and Singh, (1974).

4. 0. Result and Discussion

4. 1. Result

The results of the findings are as discussed from Figure 1, 2, and 3.

4.2. Discussion

4.2.1. Ash Content

The results of the aboratory analysis as shown in Figure 1 revealed that the ash content of fresh biomass varied from 25.0% in Control to 26.74% in MD_1 with an average of 25.79% while the digested biomass varied from 34.50% in MD_1 to 38.24% in MD_1 with an average of 35.80%. This clearly shows an increase of 38%, 43%, 38% and 36% for Control, MD_1, MD_2, and MD_3 respectively; the order being: **MD_1> MD_2 > Control > MD_3.** This order suggests that **MD_1** contained the highest mineral elements while **MD_3**contained the least of these mineral elements. In other words, **MD_1** would contained the highest amount of the following fertilizer nutrient like; **N, P, K, Ca, Mg, Mn, Zn, Cu etc.** while **MD_3** would contained the least of these vital nutrients. However, this work was in agreement with the similar work carried out by Abdullahi*et al*., (2015) and Zuru*et al* (2001).

The order is also the same as the ranking for the decrease in volatile matter content. From a similar work carried out by Abdullahi *et al*., (2015) on proximate analysis for biogas production potential of cereal straw, it was shown that, the anaerobic digestion process uses up the volatile matter thereby exposing the fertilizer contents of the biomasses. The substrate with the highest volatile matter conversion would also have the highest amount of ash content and he concluded that the mixture of Sorghum straw and Cow dung (**MD_1)** which have the highest volatile matter conversion would contained the highest amount of ash content while the mixture of Millet Straw and Cow dung (**MD_3**) which have the least conversion of volatile matter would also contained the least amount of ash content.

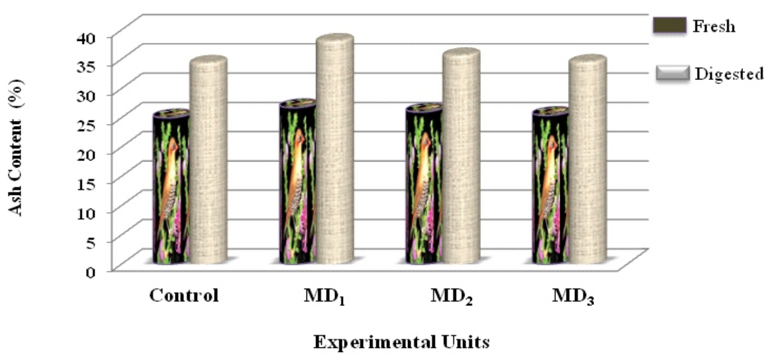

Figure 1: Ash Content Comparison between Fresh and Digested Biomass Resources

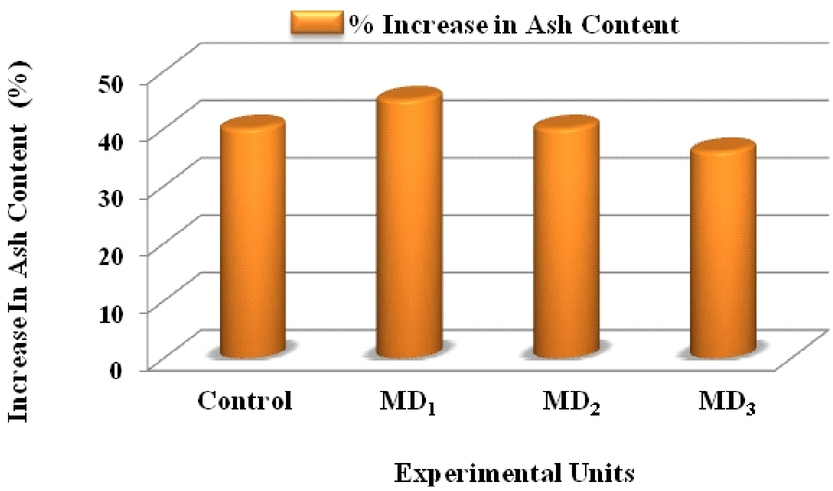

Figure 2: The Extent of Conversion of Ash Content of the Biomass Resources

4.2.1. The NPK Content

The laboratory analysis revealed that, the fresh biomasses possessed an average Nitrogen, Phosphorus and Potassium content of 1.19%, 1.36% and 0.60% respectively while digested biomasses contained an average Nitrogen, Phosphorus and Potassium content of 1.81%, 3.32% and 1.13% respectively. This however, accounted for an increase of about 52%, 144% and 88% NPK contents respectively. This clearly shows that, the NPK contents of all the biomass increased after anaerobic digestions. Therefore, digested biomass have better fertilizer quality. This increasing trend in results is in agreement with the results of ash content reported by Zuru*et al* (2006) on their research work on statistical analyses of biogas production from camel, cattle, goats, horses and sheep dungs.

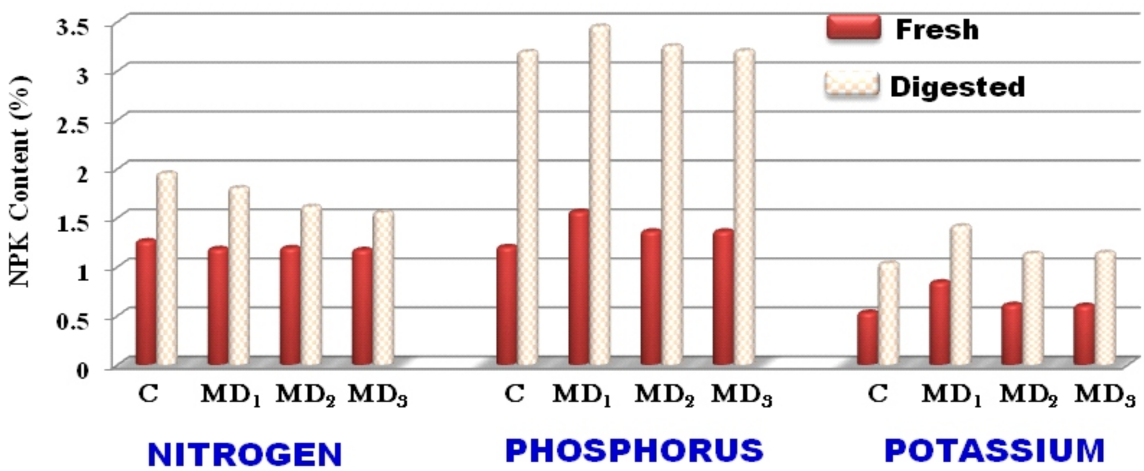

Figure 3: Comparison of N, P, K Content between Fresh and Digested Biomass

To ascertain which of these major fertilizer nutrients (N, P, K) is dominant in the digested biomass, the **N, P, K** contents of each biomass are compared in Figure 3 and the trends are given below:

N-content: MD_1 > MD_2 > Control > MD_3
P-content: MD_1 > MD_2 > Control > MD_3
K-content: Control > MD_1 > MD_3 > MD_2

The overall trend being: $\mathbf{MD_1} > \mathbf{MD_2} >$ **Control** $> \mathbf{Md_3}$

6. Conclusion

Finally, analysis on the difference in Ash contents between the fresh and digested biomass shows an increase of 38%, 43%, 38% and 36% in Cow dung (Control), Sorghum + Cow dung ($\mathbf{MD_1}$), Maize + Cow dung ($\mathbf{MD_2}$), and Millet + Cow dung ($\mathbf{MD_3}$) respectively after anaerobic digestion; the order being : $\mathbf{MD_1} > \mathbf{MD_2} >$ **Control (C)** $> \mathbf{MD_3}$**.** While the overall trend in N, P, K content after the experiment is $MD_1 > \mathbf{MD_2} >$ **Control** $> \mathbf{Md_3}$. This order suggests that $\mathbf{MD_1}$ contained the highest mineral elements or plants macro and micro nutrients such as Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Manganese (Mn), Zinc (Zn), Copper (Cu) etc. while $\mathbf{MD_3}$contained the least of these elements. Therefore, MD_1 can be concluded as the one with the best fertilizer quality. This study also identified that, the ash contents of all biomass increased to about 40% on average a after anaerobic digestions. This implies that, the digested biomasses have better fertilizing effect, because the mineral or inorganic content of biomass is reflected in their ash content. The more the ash content the higher the mineral contents (**N, P, K,** etc.) and by implication the better the fertilizer quality of the substrates.

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