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A Comparative Study on the Nutrient Composition of the Biogas Slurry and other Organic Fertilizers used by Small Scale Farmers in Kenya

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ABSTRACT

A study was taken to compare the chemical composition of three organic fertilizers; biogas slurry, farmyard manure and slurry compost used by small scale farmers in Kajiado, Kiambu and Nakuru counties in Kenya for agricultural purposes. Proper utilization of the organic fertilizers can reduce the use of mineral fertilizers by 50% therefore reducing the cost of production. Both macro and micro nutrients: Nitrogen, Phosphorous, Potassium, Calcium, magnesium, Manganese, Copper, Iron and Zinc were analysed using the Standard Operating Procedures and compared to Kenyan organic fertilizer standards. The analysis indicated great variability in the levels of the nutrient composition from one organic fertilizer type to another.

Keywords: Biogas Slurry, Mineral Fertilizer, Organic Fertilizers

I. INTRODUCTION

In most parts of Kenya there is inadequate nutrient supply to the soils and poor soil structure, these among others are the major constraints to sustainable agriculture. Major source of nutrient for plants in the soil include chemical fertilizers and organic fertilizers. Organic fertilizers are delivered from various sources mainly agricultural wastes and animal wastes. Among the many organic fertilizers existing, biogas slurry has not been fully utilized as a fertilizer yet it has great potential of improving soil productivity and crop yield through nutrient supply [14]

Biogas slurry is a by-product of anaerobic decomposition from a biogas plant. Organic wastes in cattle cow dung and agricultural wastes added to the biogas digester are converted to inorganic form during decomposition, making them more available for uptake by the plants thus contributing to improved crop yields and soil fertility [8].Proper utilization of biogas slurry can reduce dependency of many farmers on increasing expensive chemical fertilizers as it contains 20-30% more nutrients than mostly used organic fertilizers such as cow dung, farmyard manure and compost[1,15] thus saving the Kenyan economy from foreign exchange.

The composition of bio-slurry is variable depending on: the kind of dung, digestive system of the animal (ruminant or omnivore), water, species and ages of the animals, types of feed and feeding rate as well as geographic and climatic conditions in which the animals are in.The slurry is regarded as a good source of organic manure as it as it contains considerable amounts of both N, P, K and micronutrients that are necessary for plant growth (Alam, 2006)[3].

Continuous use of chemical fertilisers over time has resulted to low yield of the food crops in major agricultural areas of Kenya due to soil acidity. This situation demands to explore other supplement sources of nutrients but most farmers end up using farmyard manure only as the alternative and regard bio-slurry which is produced in large quantities across the country, as a waste which is thrown away or composted to form slurry compost.

Many technical organizations, extension services, large and small scale farmers in Kenya are often not fully aware of the multiple benefits of biogas slurry. They lack necessary practical guidance on fertilizer use efficiency of the biogas slurry due to unknown reliable estimate of nutrient composition.

The objective of the study was therefore to determine the estimate nutritional composition of the biogas slurry, compare it with other organic fertilizers commonly used by small-scale farmers and the Kenyan standard requirements for organic fertilizers.

II. METHODS AND MATERIAL

2.1 Study Area

The study area was parts of Kajiado, Kiambu and Nakuru counties in Kenya. The regions were selected because there are a lot of agricultural activities carried out in these regions and also considerably many biogas digesters systems have been set up through Kenya National Domestic Biogas programme (KNDBIP) and Biogas International Limited.

2.2 Sample Collection

Equal numbers of biogas slurry, slurry compost and farmyard manure were collected to be a representative of each county. A systematic-judgmental approach was used for sampling. A total of 90 samples were collected. The bio-slurry sample was obtained by stirring the tank in circular motion, scooping the sample into the bucket, mixing and then taking 200mls as representative to the laboratory. Slurry compost as well as Farmyard manure samples were collected from 4-5 places from the middle of the heap, sampled separately in similar polyethylene bottle of 200ml capacity, mixed thoroughly to form homogenous composite, then a representative sample packed for transportation to the laboratory for analysis.

2.3 Physico-Chemical Analysis

The collected samples were analysed for various physico-chemical parameter including: Nitrogen (N), Phosphorous(P),Potassium(K),Calcium(Ca), Magnesium (Mg), Manganese (Mn),Zinc (Zn),Copper (Cu),Iron (Fe) and pH.

Nitrogen was analysed using Kjeldahl method as described by Nyang'au *et al*., 2016[10]. Phosphorous was analysed as per AOAC 978.01, where the sample was complexed using ammonium molybdate-vanadate mixture, and then absorbance measured using UV-Vis spectrophotometer, Perkin-Elmer Lambda 25 model.

The percent K was determined by using emission mode of the atomic absorption spectrophotometer (AAS) While Ca, Mg, Mn, Zn, Fe and Cu were determined by measuring the absorbance at specific wavelength for each element using AAS, Thermo S Series Model

The pH of the biogas slurry from the different counties under study was measured within 24 hours from the time of sampling using Hanna pH meter.

Table 1: Average pH of the biogas slurry collected from different sites under study.

S/NO	Sampling area	pH Mean±SD
1	Kajiado	7.84±0.51
2	Nakuru	7.95±0.44
3	Kiambu	8.00±0.45

Table 2 : Nutritional composition of different types of organic fertilizers under study

Fertilizer type / Parameter	Biogas slurry	Slurry compost	Farmyard manure	KS 2290:2011 Limit
Nitrogen (%)	2.1427 ±0.6233	1.3768±0.4773	0.6662±0.3688	>1%
Phosphorous (%)	1.3674±0.8880	0.6997±0.4220	0.4863±0.5063	Min 5%
Potassium (%)	0.7017±0.3684	0.6715±0.3403	0.6176±0.4440	Min 5%

Calcium (%)	0.45±0.5300	1.80±0.9934	1.45±0.7544	≥1%
Magnesium (%)	0.092±0.1132	0.242±0.1409	0.179±0.1457	≥0.5%
Manganese (mg/Kg)	152.72±186.55	699.44±518.43	581.40±413.12	-
Zinc (mg/Kg)	140.59 ±127.49	277.66±141.62	238.23±112.49	-
Iron (%)	0.091±0.0789	0.403±0.2289	0.3315±0.2287	≥0.10%
Copper (%)	0.030±0.0204	0.026±0.0191	0.014±0.0102	≥0.05%

III. RESULTS AND DISCUSSION

The nutritional composition of the three organic manures were analysed and their contents is as shown in table 2 above.ANOVA test was carried out to check whether there was a significant difference in the composition of bio-slurry as compared to the other two organic fertilizers commonly used.

Nitrogen

The descriptive statistics of the total samples per category under study indicates that the bio-slurry fertilizer samples were associated with the numerically highest mean level of Nitrogen concentration, followed by the slurry compost fertilizer and Farmyard manure which had the lowest concentration of 0.6662±0.3688 as shown in table 2 above and Fig.1. On average, more than 50 % of total Nitrogen in the biogas slurry samples was ammonium-nitrogen. Both the biogas Slurry and slurry Compost met the minimum requirement of the national standard for organic manures set at 1%.

The findings of this study were similar to those of Maqbool *et al*., 2014[7], who found that the wet biogas slurry had the highest concentration of nitrogen in the form of ammonia which is readily available to plants as compared to the slurry compost. This makes the slurry a superior organic fertilizer as compared to slurry compost and farmyard manure as supported by earlier research findings of Olaniyi and Akanbi, 2007[11] and Ahmad and Jabeen., 2009[2].

The process of composting the slurry reduces the nitrogen content and increases stability of organic matter, whereas anaerobic decomposition of cow dung increases ammonium nitrogen at the same time it increases stability of organic matter, but decreases C:N ratio significantly resulting to greater availability of Nitrogen (Gutser *et al.*, 2005)[5]

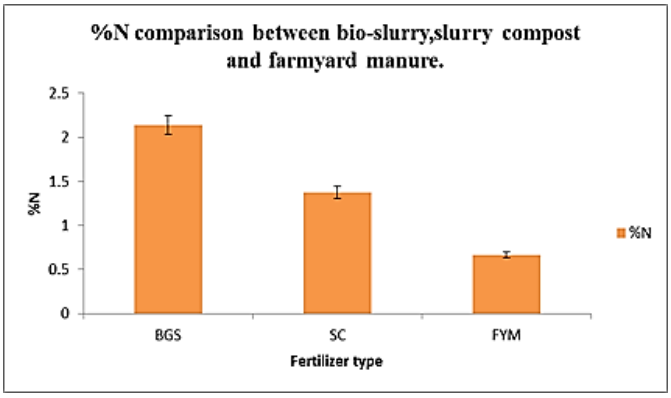

Figure 1. %N comparison in different organic fertilizers

During anaerobic decomposition, the proportion of nitrogen increases by about 20% in the bio-slurry since part of organic matter is converted to ammonium-nitrogen. Farmyard manure contains low nitrogen since most of it is in organic form, whereas the slurry compost contains slightly low nitrogen as compared to bio-slurry since part of it is lost when the slurry is composted through volatilization. The ANOVA test done on the data indicated that there was a significant difference in nitrogen composition of the biogas slurry as compared to farmyard manure and slurry compost ($P \leq 0.00$)

Phosphorous

Biogas slurry had the highest concentration of phosphorous, 1.3674±0.8880 followed by slurry compost, 0.6997±0.4220 and farmyard manure had the least concentration at 0.4863±0.5063. The biogas slurry had the highest levels of percentage phosphorous, as shown is Fig.2 below, and this can be attributed to the

fact that during anaerobic decomposition of the organic wastes in the bio digester system, there is high phosphorous mineralization achieved through neutral pH attained during decomposition. This difference in phosphorous concentration levels among the three organic fertilizers was statistically different as supported by ANOVA-test (P<0.000)

The continuous application of organic fertilizers has led to increase of phosphate in the soil .Considering the high cost of phosphatic fertilizers and environmental consideration, the exploitation of the bio-slurry as an alternative source of phosphorous will be of help to small scale farmers and reduce the cost of agricultural production significantly.

From this study, the bio-slurry seems to be the best source of phosphorous to crops as compared to other organic fertilizers. These findings agree with the findings of Seafatulluh *et al*., 2015 [12]. Their research findings indicate that the biogas slurry and vermicompost can be used as a good soil amendment as compared to cow dung since they have ability to control the pH, increase nutrient availability and control release of phosphorous fertilizer as per need of plants.

The use of biogas slurry increases the maximum phosphorous adsorption capacity (MPAC) which ensures control release of phosphorous fertilizer thus preventing eutrophication, ultimately leading to agro-environmental benefits [12].

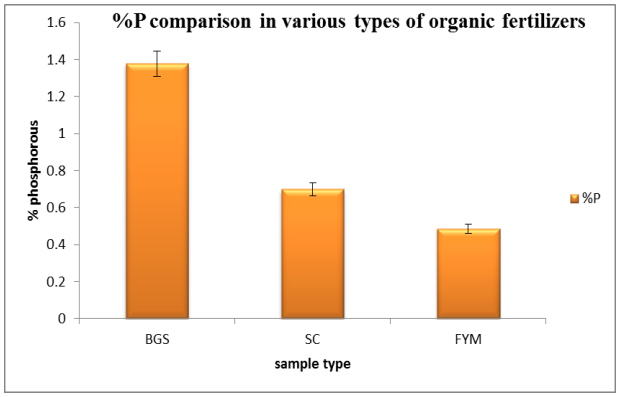

Figure 2. Phosphorous comparison in different types of organic fertilizers

Potassium

Based on each sample category of organic fertilizer under study, biogas slurry organic fertilizer sample was associated with the numerically highest mean level of percentage Potassium concentration, 0.7017±0.3684 followed by the Slurry compost fertilizer 0.6715±0.3403 and Farmyard manure had the lowest mean, 0.6176±0.4440 as shown in table 2 above.

Statistically, there was no significant difference in the concentration of Potassium in the three organic fertilizers (P=0.496) hence use of either can give similar effects on crop yield and it can supplement the mineral fertilizer on the same ratio.

pH of the Biogas Slurry

The level of the pH in the soil affects directly the availability of crucial soil nutrients needed for growth. The pH of the bio-slurry samples was determined and all the samples collected from the three counties were found to be above 7.00 as shown in table 1 above. The range of pH from the three areas under study was within the recommended range by the regulatory body in Kenya of 6.5-8.5 as per KS2290:2011.

Application of this bio-slurry to farms as a means of soil amendment will provide a buffering effect to the soil and act as a remediation to most acidic soils in most parts of Kenya protecting the crops from aluminium toxicity in the acidic soils. Buffering of soil with appropriate soil amendment is necessary for normal plant growth. The optimum uptake of most soil nutrients from the soil takes place at pH of 7.00 as the availability most nutrients like Nitrogen, Potassium, Phosphorous, Calcium, Magnesium and Sulphur decreases with increase in soil acidity [13].

Levels of Calcium, Magnesium, Manganese, Zinc, Iron and Copper in three organic fertilizers

The chemical speciation of organic manure especially of liquid manures is influenced by many factors which include; total metal concentration, conditions during digestion like pH and redox potential, and the kinetics of reduction, precipitation, complexation and adsorption [6]. The continuous application of organic fertilizers increases the micro and macro nutrient availability in the soil. Presence of these nutrients from the organic fertilizers replaces the depleted nutrients in the soil due to intensive agricultural activities carried out.

Calcium which is very essential for the plant growth was found to be the highest on average percentage in the slurry compost, 1.80±0.9934 followed by farmyard

manure, 1.45±0.7544 and bio-gas slurry had the lowest concentration of 0.45±0.5300. The high concentration in the slurry compost can be attributed to the extra plant tissue materials, ash or some household wastes added to compost pits during compost making process.

On average, the biogas slurry contains the lowest concentration of Ca content due to excessive dilution which might take place when water is added to the digester. On comparison to the requirements of organic fertilizers as per Kenyan standard, KS2290:2011, the slurry compost and farmyard manure met the requirement of the standard.

Magnesium levels in the three organic fertilizers under study were found to be 0.092±0.1132, 0.242±0.1409 and 0.179±0.1457 for bio-slurry, slurry compost and farmyard manure respectively. Although required in lesser amounts than primary nutrients NPK, percentage magnesium in the samples under study on average was less than the KS2290:2011 standard for organic fertilizer requirements of 0.5%

Manganese was highest in the slurry compost followed by farmyard manure and it is lowest in bio-slurry at 699.44±518.43, 581.40±413.12 and 152.72±186.55 respectively. Manganese is one of the micro nutrients which are required in small quantities by plants but crucial for plant development. The Kenya standard, KS2290:2011 does not have the minimum requirement for Manganese in organic products.

The levels of Micro-nutrients Zinc Iron and Copper in bio-slurry, farmyard manure and slurry compost had a wide variation. Copper was highest in the bio-slurry, followed by slurry compost and lowest in farmyard manure at 0.030±0.0204, 0.026±0.0191 and 0.014±0.0102 respectively. Zinc which aids plant growth hormones and enzyme system and seed formation was highest in the slurry compost, followed by bio-slurry and lowest in the farmyard manure.

The levels of Iron were 0.091±0.0789, 0.403±0.2289 and 0.3315±0.2287 for biogas slurry, slurry compost and farmyard manure respectively, with the slurry compost having the highest concentration of percent iron content. All the organic fertilizer under study met the minimum requirement for iron organic manure as per the Kenyan organic fertilizer standard, KS2290:2011.

Materials added to the biogas digester reactor apart from the diet of the animal, affect the nutrient composition of the biogas slurry. The levels of zinc, copper, iron and manganese in this study are within the range Nicholson *et al*., 1999 [9] and those cited by Barbazan et al., 2011 [4].To some extent there is a high correlation of the levels of the nutrient present in the organic manures under study with the concentration in the animal feed and conversion efficiency of the animals.

IV. CONCLUSION

The study established that there was great variability in nutritional composition of the biogas slurry, farmyard manure and slurry compost. There was a significant statistical difference in the nutrient levels of Nitrogen and Phosphorous within the biogas slurry, slurry compost and farmyard manure ($P<0.05$). The high concentration of nitrogen in the bio-slurry is attributed to the conversion of organic compounds during anaerobic decomposition to readily available Ammonium-Nitrogen. This is an indication that the bio-slurry is a better organic fertilizer than the other commonly used organic fertilizers as soil amendments. All organic fertilizers under study contains sufficient amount of macro and micro nutrient for examples Calcium, Magnesium, Manganese, Copper, Iron and Zinc besides appreciable quantities of organic matter which are essential to plant growth and development.

A few of the parameters analysed in the organic fertilizers met the minimum requirement of the organic manure as declared by the local Kenyan standard, KS2290:2011.

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