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Characterization and Utilization of Bioslury from Anaerobic Digester for Fertilizer in Crop Production

Kefale Wagaw*

Faculty of Chemical and Food Engineering, Bahir Dar University, Bahir Dar, Ethiopia

Abstract

In biogas plant there is a release of mainly two products. Methane gas which use for different purpose like cooking, lighting and slurry which can be used as organic fertilizer. The main target of this study was characterizing the slurry by measuring the relative amount of macro and micro nutrients like Nitrogen, Phosphorus, Potassium Calcium, Magnesium, and Manganese by using standard methods. And comparative study of the organic fertilizer at different treatments with commercial fertilizer on selected crops. Potassium and Calcium (part of plant cell wall) show positive deviation when it was composted.

Keywords: Biogas slurry; Compare; Compost; Macro; Micro-contents

Introduction

Agriculture contributes for more than 46% of the GDP and 90% of the export earnings, and supports 85% of the labour force of Ethiopia. Most farmers in the country use traditional way of agriculture using chemical fertilizer [1]. This chemical fertilizer is costly and decrease fertility of soil from time to time. To overcome this problem Organic manures such as cow dung, poultry manure, crop residues and biogas slurry in liquid and composted form can be used as organic fertilizer [2]. Bioslury obtained from the biogas plant may be considered as a good source of organic fertilizer as it contains considerable amounts of both macro and micronutrients, so using organic fertilizer (bioslury) can have economical value chain in crop production. Bioslury is an anaerobic digested organic material released as a digestant from the biogas plant after production of combustible biogas for cooking and lighting. Biogas slurry is a good source of plant nutrients and can improve soil fertility and properties. These nutrients are mainly nitrogen, phosphorus and potassium (macro) and magnesium, calcium and manganese (micro) elements and characterizing these nutrients using ICP, Spectrophotometer and Kjeldahl method [3] will be the major task of the project.

The value of bio-slurry as a fertilizer depends on the nutrient contents, e.g., the amount of nitrogen, phosphorus, potassium, calcium and magnesium [4], the ratio between nutrients in the bio-slurry, e.g., the N/P-ratio and/or the N/K-ratio [5]; and the availability of the nutrients, which is determined by the compounds that contain the nutrients. Farmers can use bioslury as liquid form ancompost form. Compost is an aerobically decomposed organic material [6] derived from plants and animal source.

Composting is a natural process of decomposition of organic matter by microorganisms under controlled conditions. During composting there will be loss of important nutrients like ammonia the basic source of Nitrogen and it is better to characterize before and after composting. Therefore characterizing the slurry and trying to analyze its content will motivate societies of our country to implement biogas plant in small scale which have triple value: energy interms of heating or lighting, organic fertilizer, and clean environment. After characterizing both soil and compost the demand gap of nutritional content was investigating. Finally this experiment was validated by growing crops based on characterization results [7].

When plant materials or animal manure is added to the soil, it does not stay in its original form for long. It is immediately attacked by a host of different soil organisms and undergoes a complex series of biochemical steps leading ultimately to its complete breakdown. The bulk of the material undergoes an oxidation or burning' process in which the carbon and hydrogen which make up about half of the dry weight of organic matter combine with oxygen to produce carbon dioxide and water. Energy is released in the process, and this is what is used by bacteria and other soil microorganisms for their survival and growth.

As the basic structure of the plant material is broken down (the breakdown may start from a series of intermediary steps like the digestive system of living creatures and anaerobic fermentation process or it may start from the soil itself if these materials are returned to the soil as such), nutrients such as nitrogen, phosphorous, potash, sulphur, etc., are released from their original organic form. Part of These may become soluble, and therefore be immediately available to growing plants. Most are, however, taken up by microorganisms and stored in their tissues as they grow and multiply [8].

These are only released when original plant matter has been used up and the organisms themselves start to die off and decompose. A variety of complex organic products accumulate in the soil as the process of decomposition continues. These include lignins and other materials that are resistant to decomposition as well as polymers derived from microbial products [9]. This more or less stable fraction is called humus. It is usually dark in color and persists in soil for many years, degrading very slowly but being replenished each year by the new additions of organic materials. The breakdown of organic matter depends on a variety of soil and site conditions. Nutrient and pH status, moisture content and temperature, and the availability of oxygen for soil microorganisms affect the rate of breakdown of organic materials [10].

***Corresponding author:** Kefale Wagaw, Faculty of Chemical and Food Engineering, Bahir Dar University, Post Box 26, Bahir Dar, Ethiopia, Tel: +251582205925; E-mail: wkefale@yahoo.com

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Scope

This research was confined to the effects of digested slurry and compost on crop production in the existing agro-ecological conditions and the prevailing socio-cultural milieus in piccolo and adjacent areas with similar agro-ecological and socio-cultural environment [11].

Materials and Methods

Raw material

Main raw materials to do this project are animal manure, biogas slurry liquid type and solid type (compost).

Chemicals

Metallic salts such as calcium chloride (Figure 1) hydrated with two molecules of water, manganese sulphate hydrated with 1 molecule of water, potassium nitrate and magnesium nitrate with 6 molecule of water were used to prepare standard solution to Ca, Mn, K and Mg. During this experiment we used concentrated nitric acid, peroxide ammonium, Molybdenum antimony potassium tartrate [12], ascorbic acid and KH_2P0_4 to determine nitrogen we used Kjeldahl method.

Equipment

During the experiment in this project we used inductively coupled plasma atomic emission spectroscopy ICP-AES also known as ICP-OES as the main equipment to analyze amount of metals such as K, Mg, Ca and Mn of the manure [13], the biogas slurry and compost. The other equipment we used to measure the nutrient was spectrophotometer to measure the amount of non-metallic nutrients like phosphorus. To determine nitrogen it was used Kjeldahl method. During this method equipments like flask, stove and condenser were used, and the third equipment used was colony counter to measure the bacterial load in the sample. In this experiment we used homogenizer, sterilizer, and test tube. In this project we used volumetric flasks with volume 50 ml, 100 ml, 500 ml and 1000 ml and electronic balance.

Methods

Sample collection

Three samples from three different treatment stages were collected from piccolo, west Gojjam, Ethiopia. Each sample was collected in separate plastic bags and labelled.

Macro and micro nutrients determination standard preparation

To measure metallic nutrients standards was prepared and Nitric acid was used to digest the solid sample [14]. To prepare standard solution to determine calcium, manganese potassium and magnesium concentration in each samples their salts $CaCl_2.2H_2O$, $MnSO_4.H_20$, KNO_3, $Mg(NO_3)_2$ respectively are used.

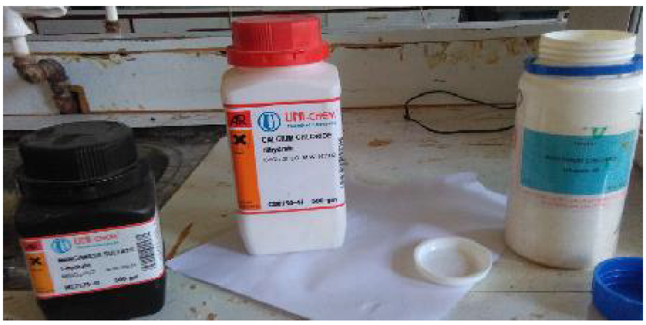

Figure 1: Salts used for standard solution preparation.

Digestion of samples

Since the ICP analyzes the solution in pure liquid form the solid and turbid liquid samples were digested using concentrated nitric acid [15]. 1 gm of each sample (manure, slurry and compost) was measured and 8 ml of HNO_3 was added to each samples. This mixture of sample was digested with microwave digester at 200°C for 30 minutes.

Working solution preparation

There were three samples for each of four metallic elements. These were at 5 ppm, 10 ppm and 20 ppm by 100 ml volumetric flask. These three samples of four elements (total of 12 samples) were prepared by 100 ml of volumetric flask with standard solution [16]. These working solutions were given to the ICP and the result was read as mg/l.

Phosphorus concentration determination Stoke solution preparations

Stock solution A: 12 gm of ammonium molybdate was dissolve in 250 ml of distilled water and 0.2908 gm antimony potassium tartrate was dissolved in 100 ml of distilled water. Finally both of these solutions were added to 1000 ml of 5N H_2SO_4 This solution was made 2000 ml with distilled water.

Solution B: 1.056 gm of ascorbic acid was dissolved in 200 ml of solution A and mixed thoroughly (Figure 2).

Digestion: 1 gm of each sample was weighed and 20 ml of HNO_3 was added to the samples. This was heated at 130°C until white dense fume appear then 10 ml of H_2O_2 was added to each sample and farther heated at 200°C.

Calorimetric determination of phosphorous

Digested sample was filled to 50 ml flask. 10 ml of solution B was added and the flask was filled to 50 ml with distilled water finally read the solution at 880 maxima using spectrophotometer (Ultima-2).

Nitrogen concentration determination

The method consists of heating a substance with sulphuric acid, which decomposes the organic substance by oxidation to liberate the reduced nitrogen as ammonium sulphate. In this step potassium sulphate was added to increase the boiling point of the medium (from 337°C to 373°C) Chemical decomposition of the sample is complete when the initially very dark-colored medium has become clear and colorless. The solution was then distilled with a small quantity of sodium hydroxide, which converts the ammonium salt to ammonia. The amount of ammonia present, and thus the amount of nitrogen present in the sample, is determined by back titration. This done by Kjeldahl method.

Digestion: The sample to be analyzed was weighed on an analytical balance into the digestion flask. Then the sample is digested by concentrated H_2SO_4.

Distillation: After digestion was completed, the content in the flask was diluted by water and a concentrated NaOH is added to neutralize the acid and to make the solution slightly alkaline.

Titration: If boric acid is used, the titration is called an indirect titration, because the ammonia that is chemically equivalent in converting the boric acid (ammonia bound to an equivalent of borate ion) is directly titrated with standard acid (0.1 N HCI).

$NH_3+H_3BO_3$-----$NH_4^++H_2BO_3^-$

Liberation of ammonia $(NH_4)2SO_4+2NaOH$---$Na_2SO_4+2H_2O+2NH_3$

Capture of ammonia $B(OH)^3+H_2O+NH_3^+$---$NH_4+B(OH)_4^-$

$\% N_2=(V_{Hcl} \times N_{Hcl} \times m_{wn}/wt) \times 100$

Results and Discussion

Elemental composition of bioslury before and after treatment

As it was investigated in results of metallic nutrient determination K and Ca (part of plant cell wall) show positive deviation when it was composted. This is because of that decomposed vegetables are This is because of that decomposed vegetables are sources of both Ca and K during composting While Magnesium and Manganese show negative deviation from slurry to compost (Table 1).

Nitrogen decrease (33%) during composting (Table 2) this is due to volatilization of N_2 in the form of NH_3 and NH_4. This phenomenon will increase at low PH value. Orthophosphate which is found in the soil is the main source of phosphorous. Due to this P value increases during composting. According to the results of this project it is possible to conclude that biogas slurry has considerable amount of both macro and micro nutrients which have significant role to minimize the consumption of chemical fertilizer. During composting the phosphorus concentration increase from 0.2 (mg/l) to 0.3 (mg/l) (Table 3).

Table 4 shows that the biogas slurry was not able to achieve higher incremental onion yield (Figure 3) as compared to compost and commercial fertilizer. But both compost and commercial fertilizer have equal productivity for onion cultivation. Compost, in fact gave the highest incremental yield of chills as shown in Figure 4 (even higher than that of chemical fertilizer). The researcher comments: "From these simple field trials my observations do not confirm with the results other scientists found in other parts of the world. Even if biogas slurry has higher nitrogen content its productivity on selected crops is low. There

Figure 2: Standard solution preparation.

Sample	Potassium concentration [mg/l]	Calcium Concentration [mg/l]	Magnesium Concentration [mg/l]	Manganese concentration [mg/l]
Manure	66.92	0.84	5.11	56.50
Slurry	107.56	0.69	2.3	46.16
Compost	146.11	2.22	4.91	55.35

Table 1: Metallic composition of bioslury sources of both Ca and K during composting while Mg and Mn show negative deviation from slurry to compost.

S. No.	Sample	V_{HCl} (ml)	^{N}HCl	M_{wn} (g)	Wt (g)	N_2%
1	Compost	3.6	0.1	14.1	0.3	1.68
2	Manure	4.5	0.1	14.1	0.3	2.10
3	Slurry	5.4	0.1	14.1	0.3	2.52

Table 2: Nitrogen composition of bioslury.

S. No.	Standard	Absorbance		Sample	Absorbance		Phosphorus Concentration (mg/l)
		690 nm	880 nm		690 nm	880 nm	
1	0.0 ppm	0.00	0.00	Manure	0.095	0.099	0.22
2	0.5 ppm	0.02	0.02	Slurry	0.089	0.093	0.2
3	1.0 ppm	0.03	0.04	Compost	0.092	0.097	0.33

Table 3: Phosphorous composition of bioslury.

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A. Compost B. Fertilizer C. Slurry

Figure 3: Productivity of organic fertilizer on onion.

A. 1. Observing productivity with fertilizer 2. Side view of the chills using compost

B. 1. Sectional view of chills prod by compost 2. Side view on chills prod by slurry

Figure 4: Productivity of organic fertilizer on Chills.

	Fertilizer Type	Land Area [m²]	Produced Crop [kg]	Yield [kg/m²]	Earned money
Onion	Slurry	2 × 4	5	0.83	232 ETB
	Compost	2 × 4	12	1.5	
	Commercial fertlizer	2 × 4	12	1.5	
Chills	Commercial fertlizer	2 × 4	28	3.5	1560 ETB
	Compost	2 × 4	30	3.75	
	Slurry	2 × 4	20	2.5	

Table 4: The yield of chills and onion.

may be several factors which were not looked upon in detail during these trials. This particular experiment did not furnish information on the form of slurry used, the possible toxic effect of biogas slurry, presumably in its fresh liquid from. The claim of toxicity is not verified by further research in Ethiopia.

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