

COMPARISON OF NITROGEN, PHOSPHORUS AND POTASSIUM CONTENTS IN COW DUNG AND SLURRY GENERATED IN BIOGAS PLANT

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ABSTRACT

Cow dung is the major source of biogas production. Cow dung and slurry both are being used as organic fertilizer for agriculture. This study was conducted in 2011 to analyze the value of nitrogen, phosphorus and potassium (NPK) in cow dung and slurry generated in biogas plant. Nitrogen contents in cow dung and slurry were determined by Kjeldahl nitrogen assembly apparatus. The concentration of phosphorus and potassium were determined by using spectrophotometer and flame photometer, respectively. Results revealed that mean concentrations of nitrogen (0.931 ± 0.0259) and potassium (153.2 ± 25.3) were high in slurry whereas the concentration of phosphorus (84.021 ± 1.641) was high in cow dung. The study suggests that slurry is an effective and rich fertilizer as compared to cow dung.

KEYWORDS: Cow dung; slurry; biogas plant; bio-fertilizer; renewable energy; Pakistan.

INTRODUCTION

Biogas is a renewable source of energy, especially in countries where livelihood is based on agriculture and dairy development. Hike in oil prices in the West has compelled the policy makers to focus on anaerobic digestion thus making best use of available natural resources in countries like India and Pakistan (1). There are more than 3.2 million biogas plants in the world, whose slurry (around 28 million tons) may be utilized as a unique organic source of plants nutrients (12).

In Pakistan, during 1980, it was proposed to set up 15000 biogas plants in the country covering some 2000 villages under demonstration programme. Pakistan Council of Appropriate Technology (PCAT) under propagation of

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biogas programme in 1976 installed 21 Chinese type biogas plants to assess workability of these plants under different climatic conditions prevailing in the country (13).

During the process of biogas generation, cow dung is used as major source for digestion as it is easily available in rural areas. Cow dung is traditionally considered as an organic fertilizer. Organic fertilizers are soil amendments derived from natural sources to maintain the minimum percentage of nitrogen, phosphorus and potash in the soil. Other kinds of organic fertilizers include plant and animal by-products, rock powders, seaweed, inoculants, and conditioners (5).

During the digestion process in biogas plant, cow dung if fermented gives a mixture of carbon dioxide (27.2%) and methane (67.9%) in the proportion of 1:2.5 (18). The mixture gas is used as kitchen gas and can also be easily used for the generation of electricity. Due to fermentation in digester odorless slurry that comes out from digester becomes better manure since NPK, value rises this slurry. After giving away the gas slurry can be dried and sold as manure (11). The biogas slurry containing 1.4 to 1.8% of Nitrogen, 1.1 to 1.7% phosphorus (as P_2O_5) and 0.8% to 1.3% potassium (as K_2O) is used as organic manure. Since such organic manure is highly rich in nitrogen, it has high nutritional value. For example the use of higher levels of nitrogen i.e. 150, 200 and 250 kg per hectare had a beneficial effect on fresh top weight as well as root yield of radish (9).

Animal manure used for biogas production does not lose its nutrients value (7). This slurry satisfies the needs of farmers for fuel and manure (10). Organic compound fertilizers are eco-friendly and may combine the best qualities of compost and chemical fertilizers in cost effective manners. However, the quality control of organic compound fertilizers and of compost is of critical importance (3). In a study conducted by Akhtar *et.al.* (2) it was found that a combination of the organic manure with inorganic fertilizers was a cost effective method to improve the soil fertility and increase crop yield.

The present study aims to compare NPK values in cow dung and slurry in biogas plant and to evaluate whether direct application of cow dung is more effective than slurry or not so that may be advised people about the use of bio fertilizers and waste management in judicious way.

MATERIALS AND METHODS

This study was carried out at Lahore College for Women University, Lahore, Pakistan during 2011. The samples of cow dung and biogas slurry were collected from the biogas plants installed by Pakistan Dairy Development Company (PDDC) at following locations in Lahore. Location

1. Location A: Kot Lakhpat plant of PDDC, Location
2. Location B: Mehmood Botti Dairy Farm (MBDF)
3. Location C: Malik Dairy Farm (MDF).

A total of 18 samples were collected from these three sites which nine samples of cow dung and nine samples of biogas slurry. Composite sampling procedure was adopted for sample collection. The study was limited to specific time of three months during summer season. Hence, nature and quality of cow dung varied depending on the seasonal fodder and substitute food.

Analysis of nitrogen contents in cow dung and slurry

Concentration of nitrogen in samples of cow dung and slurry was determined by Kjeldahl method using automatic distillation plant (Inkjel M, Behr labor–Technik GmbH, D-40599 Dusseldorf). This method is divided into 3 steps of digestion, distillation and titration (4)

Digestion: One gram of cow dung and 1 gram of biogas slurry from each of nine representative samples were weighed by using electrical balance (Sartorius TE 313S-DS). The samples were first digested in digestion flask using digester. Each sample was dissolved in 15ml of concentrated sulphuric acid along with half tablet of catalyst (selenium mixture). First flask of Behr Inkjel M nitrogen assembly left empty (as blank sample). Samples were then placed in flasks. The digestion flasks of Behr Inkjel M Nitrogen Assembly were then placed into the digestion rack and heated at 100°C for 90 minutes until white fumes stopped emerging from the sample and clear solutions were formed. Samples were then kept for cooling by adding small quantity of distilled water in it.

Distillation: After cooling, the samples were run in distillation assembly. It was accomplished by raising the pH with 40% sodium hydroxide (NaOH) for changing the ammonium to ammonia. Then 4% of boric acid was taken in conical flask for trapping the ammonia during distillation. First of all blank

sample was run in distillation unit and then remaining 18 samples were run in the same way.

Titration: After distillation, the boric acid was titrated against N/0.01% hydrochloric acid (HCl) by using mixed indicator of bromocresol green and methyl red. The values of titration were noted for all samples of cow dung and slurry. The solutions of cow dung and slurry were titrated until the color of the solutions changed to light pink, reading was noted and values were used to calculate the concentration of nitrogen in all samples using following formula.

$$\%N = (A - B) \times N \times E \times R \times 100 / \text{weight (mg)}$$

Analysis of phosphorus in cow dung and slurry

The concentrations of phosphorus in cow dung and biogas slurry were determined by using spectrophotometer. The dung and slurry samples were passed through the procedure of dry ashing for estimation of phosphorus (17).

Dry ashing: One gram of each cow's dung and biogas slurry was weighed using electrical balance. Samples were taken in boron free fused silica crucibles. The crucibles were placed in muffle furnace and the temperature was increased gradually upto 450°C. The materials were ashed for at least one day and the furnace was cooled after one day. The crucibles having ashed samples were removed from muffle furnace and 10 ml of 0.7N sulfuric acid (H₂SO₄) reagent were added. The mixture was mixed well and allowed to stand for one day. The samples were filtered in 50 ml volumetric flask using Whatmann No.42 and the volume of samples was raised to 50 ml using distilled water. The samples were stored in bottles at a cool-dry place.

Estimation: Different standards of phosphorus were required for estimation of phosphorus. Different standards were formed i.e., 2, 4, 6, 8, and 10 ppm from this stock solution, Then 5 ml of each standard was taken and 10 ml of ammonium vanadomolybdate was added and final volume was raised to 50 ml using distilled water. Similarly, 5 ml of each cow dung and biogas slurry samples was taken and by addition of ammonium vanadomolybdate, the volume was raised to 50 ml with distilled water. The percentage absorbance value of standards was observed with the help of spectrophotometer (Spectroscan 80D UV-VIS Spectrophotometer) at 410 nm and a graph was plotted of standard curve of phosphorus. Similarly, the absorbance value of

each sample was noted and these values were observed in standard curve of phosphorus showing phosphorus in parts per million.

Analysis of phosphorus and potassium in cow dung and biogas slurry

The concentrations of potassium in samples of cow dung and biogas slurry were determined by using flame photometer. The samples were passed through the procedure of dry ashing for the estimation of potassium. After dry ashing, the samples were then placed in the flame photometer one by one and the color of flame and its intensity was noted for each sample, which tells what element is present and in how much quantity, respectively. The readings for the concentration of total potassium in samples were noted (17). Analytical results of cow dung and slurry samples were statistically compared by mean, ± standard deviation (SD) and T-test by using computer software Minitab Version 13.

RESULTS AND DISCUSSION

The results showed that mean amount of nitrogen in the sample of slurry was higher (0.931± 0.0259%) than those of dung (Table 1). The comparison the mean concentration of phosphorus showed that mean value of phosphorus in cow dung was higher 84.021±1.641 as compared slurry samples (28.55± 4.11 ppm). The value of T-test is greater than 0.001 and is highly significant.

Table 1.

Similarly mean concentration of potassium showed that sample of slurry had higher mean concentration of potassium i.e. 153.2 ± 25.3 than cow dung (82.22 ± 18.78 ppm). The probability value for T-test in slurry is less then P<0.05 and is highly significant.

Table 1. Comparison of mean NPK in cow dung and slurry samples.

Sr. No.	Sample Type	Nitrogen (%) (Mean ± S.D.)	Phosphorus (ppm) (Mean ± S.D.)	Potassium (ppm) (Mean ± S.D.)
1.	Cow dung	0.451 ± 0.0285	84.021±1.641	82.22 ± 16.78
2.	Slurry	0.931 ± 0.0259	28.55 ± 4.11	153.2 ± 25.3

The comparison of mean value of NPK in cow dung and slurry samples collected from different sites (Table 2) showed high value of mean nitrogen in slurry sample (0.961±0.010%) at location where high value of phosphorus (86.27±1.188 ppm) was noted in cow dung sample. Potassium was also found high (180.0±20.0 ppm) in slurry samples collected from same location.

Table 2. Comparison between mean value of NPK in cow dung and slurry form different sampling sites.

S. No.	Location	Cow dung			Slurry		
		Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)
1.	A	0.423±0.025	84.28±1.397	80.33±3.510	0.919±0.010	24.33±2.080	150.0±30.0
2.	B	0.450±0.020	86.27±1.188	100.0±17.30	0.961±0.010	29.67±3.060	180.0±20.0
3.	C	0.480±0.010	83.01±2.080	61.0±11.53	0.916±0.017	32.33±3.060	129.7±20.5

A = Pakistan Dairy Development Company (PDDC) Kot Lakhpat Plant, B = Mehmood Booti Dairy Farm, C = Malik Dairy Farm (MDF).

The nutrients (NPK) present in waste are usually in complex organic form that is difficult for the crop to uptake. The biogas digester slurry acts as a soil-conditioner and helps improve the physical properties of soil (16).

It may be concluded that mean nitrogen concentration in samples of cow dung was lower than the mean concentration of nitrogen in slurry sample. The reason is that slurry being the thermophile bacteria breaks down the organic wastes and fix the amount of nitrogen in it during the anaerobic fermentation of cow dung in biogas plant. According to Gurung (8) digested slurry contains the higher amount of mineral nitrogen than fresh dung and dung mixed with water. However, in cow dung the nitrogen concentration may be lost because of different reasons. As during sun-drying operation, the manure lost nitrogen roughly equivalent to the whole of free ammonia present.

The comparison of mean phosphorus concentration in cow dung and slurry revealed that phosphorus concentration in the sample was high. The reason of the high value of phosphorus in cow dung samples was better housing system and waste handling methods. Nutrients in waste may be lost or converted to other forms during treatment or storage and handling. This affects their availability to growing plants (6). In present study concentration of nitrogen and potassium was high in slurry samples rather than cow dung samples. This may be due to the anaerobic digestion of waste in the digester. According to Nayono and Satato (14), anaerobic digestion process can be termed as wet and dry digestion depending on the total solids concentration of the feed substrate. The slurry which comes out of a biogas unit constitutes good quality manure free from weed seeds, foul smell and pathogens. It contains a full range of plant nutrients in the digested slurry (15).

CONCLUSION

It is concluded that cow dung and slurry generated at biogas plant are richer in macronutrients required for plant growth as nitrogen fixing bacteria fix more nitrogen due to anaerobic fermentation. Hence, the farmers should be advised to use cow dung and slurry as organic fertilizers instead of chemical fertilizers because the farmer is more economical.

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