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Biogas Slurry: Source of Nutrients for Eco-friendly Agriculture

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Abstract
Biogas plant (BGP) with anaerobic digestion providing a facility to generate manure (Biogas spent slurry) and energy generation. The digested biogas slurry (DBGS) is rich in macro and micro nutrients that provide essential plant nutrients for longer period. Biogas slurry may be considered as a good quality organic fertilizer for sustainable agriculture. Biogas slurry provides huge nutrient potential for vegetative and reproductive growth of field crops with long term sustainability. By applying the digested biogas slurry (DBGS) in the field for long term basis help in reducing fertilizer demand and provide an eco-friendly way of maintaining productivity and soil health. In this study we are summarizing nutrient potential of digested biogas slurry (DBGS) and relation with synthetic fertilizers in India, as a potential source.

Keywords: Digested biogas slurry (DBGS), Nutrients, Sustainability, Fertilizers.

Introduction
Biogas slurry is a by-product of anaerobic digestion that produced from biogas plant and also produces biogas (combustible methane gas) that is used for cooking, lighting and running engines. Bioslurry can be used to fertilize crops directly or added with other organic materials and synthetic fertilizers. Bioslurry is a digested source of animal waste and if urine (animals) is added, more nitrogen is added to the bioslurry which can speed up the compost-making process in short period of time. This improves the carbon/nitrogen (C/N) ratio in the slurry that provides easily nutrient availability to plants and soil biota.

The biogas slurry has 93% water and 7% of dry matter, of which 4.5% is organic matter and 2.5% inorganic matter. The digested biogas slurry also contains phosphorus, potassium, zinc, iron, manganese and copper, out of which many depleted from soil due to intensive agricultural practices. Bioslurry can also be used to build up health fertile soil for crop production. Bioslurry contains easily-available plant nutrients and it contains higher amounts of nutrients and micronutrients than composted manure and FYM (Ishikawa et al. 2006). The effects of bioslurry application are comparable to the effects of the application of synthetic fertilizers. Hence, digested bioslurry can be a precious alternative to synthetic fertilizers. Biogas slurry is considered a good source of organic fertilizer as it contains considerable amounts of both macro (N, P, K) and micronutrients (Zn, Mn, B) that are necessary for plant growth (Alam, 2006). Use of biogas slurry is providing a sustainable way for agriculture, environment and farming communities.

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Survey
Potential of cattle dung in India
India has huge number of livestock population near about 512.05 million heads in 2012 (Dhikshit et al. 2010). In India, the total estimated potential of biogas plant is 12 million but till now 4 million plants are installed which can generate daily on an average basis (**Table 1**) about 35 million cubic meter of biogas. So that, there is only near about 33% of the potential over the period of almost 40 years has been achieved by this cumulative installation of biogas plants (MNRE, 2004). The dung production capacity of animals varies according to local conditions and feeding habit.

Table 1. Per day dung production rate (Nagamani et al. 1999)

Head	Dung (Kg/day)	Biogas yield (m^3/Kg)
Cattle	10	0.36
Buffalo	15	0.54

Table 3. Comparison of nutrient content in FYM, compost and biogas slurry (SNV, 2011)

Organic material	N (%)	P (%)	K (%)
FYM	0.5-1	0.5-0.8	0.5-0.8
Compost	0.5-1.5	0.4-0.8	0.5-1.9
Biogas slurry	1.4-1.8	1.1-2	0.89-1.2

Total dung produced by animals in India is 730 MT per annum (per day 2 MT dung), out of which only 60 % dung is recoverable (collection rate varies from 58 % to 65 %). But we are basically meeting our demand of dung through bovine dung (cattle+buffalo). They generate only 256.2 MT dung each year that also have huge nutrient potential to fulfil our fertilizer demand. On an average by 1 kg cattle dung only 0.3 kg slurry produced. So that total slurry produced in India is 76.8 MT/year. On an average composition of biogas slurry is 1.5% N, 1.1% P and 1% K (**Table 2**).

Comparison of nutrition values

The slurry can with easily be brought to places that need organic fertilizers. The most important benefit is that the slurry is a very effective fertilizer that can improve the growth of the crops (Ahmad et al. 2009). Nitrogen is one of the major nutrients required for plant growth. Biogas slurry contains a considerable amount of both macro and micro nutrients besides appreciable quantities of organic matter than other organic fertilizers like FYM and compost (**Table 3**). The concentration of toxic heavy metal is very low compared to synthetic fertilizers. Biogas slurry (organic fertilizer) is environmental friendly, has no toxic or harmful effects and can easily reduce the use of synthetic fertilizers. The use of synthetic fertilizers began in the country from 1960s with huge amount and demand sharply increased with the introduction of high yielding varieties of crops (MNRE, 2010).

Combined effect of biogas slurry (Dry-DBGS & Wet-DBGS) and synthetic fertilizers

As we know, in traditional agricultural systems very less or no synthetic fertilizers are applied, breakdown of organic materials supplies the dominant portion of nitrogen, phosphorous and sulfur that play important role in plants metabolism. Organic matter

Table 2. Nutrient composition of biogas slurry

Sl. No.	N (%)	P (%)	K (%)	References
1	1-1.8	0.8-1.2	0.8-1	Gupta, 1991
2	1.4-1.8	01-Feb	0.8-1.2	DST, GOI (1981)
3	1.5-2	1	1	Tripathi, 1993
4	1.5	0.4	2.2	Board, 2007
5	1.3-2.5	0.9-1.9	1	Myles et al. 1993
6	0.5-1.0	0.5-0.8	0.6-1.5	Demont et al. 1990
7	1.5-2.0	1	1	Khandelwal et al . 1986

Table 4. Comparison of the effects of DBGS and FYM on the yield of crops

Crop	Yield (kg/ha)		% increment
	DBGS	FYM	
Cotton	154.5	133.5	6.5
Wheat	450	390.5	8.9
Maize	555.9	510.4	15.2
Rice	634.4	597.5	15.7

greatly enhances the cation exchange capacity (CEC) of the soil that has ability to capture positively charged ions such as Mg, Ca, K and NH_4^+. On other hand, when the CEC is low, these nutrients would be rapidly leached away when it rained. Cation exchange ability of the organic matter is particularly important in acid soils, and those with low clay content since such soils have low binding ability.

The combination of biogas slurry and synthetic fertilizers enhances the C:N transformation on the crop and increases the yield by 6.5%, 8.9%, 15.2% and 15.9% of cotton, wheat, maize and rice respectively (**Table 4**). The effect of biogas slurry depends on the absorption rate of the crop at the time of application. Some studies also showed that the yield of corn can increase by 7% (Shahabz, 2011) and can be increase by 8.9% (SNV, 2011). Other research shows that an application of 12 t/ha can increase the yield and nutritional value of maize more than 10 t/ha or 14 t/ha of manure application (FYM). The highest biomass yield of maize fodder can be observed with 54.12 t/ha of biogas slurry application. There is no significance increase in numbers of leaves with combined effect of biogas slurry and synthetic fertilizer. The following **Table 5** shows that biogas slurry is not superior in terms of its manurial properties as compared to both different combination of dry slurry (Dry-DBGS) and synthetic fertilizer or alone. Dry slurry (Dry-DBGS) showed the lowest increment in wheat yield, probably indicating the loss of nutrient during the drying operation. Here, maximum increment was shown in application of synthetic fertilizer alone. But it is not an appropriate way to maintaining the sustainability of soil and produce for long period.

During digestion of biogas slurry, nutrients are transformed from organic form to dissolved states (inorganic form), making them more useful for plant uptake (Lansing et al. 2010). It is observed that generally the rate of application of bioslurry is 10 to

Table 5. Effect of wet and dry biogas slurry (DBGS) on wheat yield (Bhattarai et al. 1988)

Sl. No.	Treatments	Yield (t/ha) (3 years average)	Increment over control (t/ha)
1	Control	1.28	-
2	Dry-DBGS	1.45	0.16
3	Wet-DBGS	1.84	0.55
4	50% Dry-DBGS+50% synthetic fertilizer	2.7	1.41
5	75% Dry-DBGS+25% synthetic fertilizer	1.74	0.45
6	Synthetic fertilizer	3.5	2.21

20 t/ha in irrigated field and 5 tons/ha in dry farming in order to achieve a significant increase in productivity (SNV, 2011). Generally the additional increase in yield is not more than 25 t/ha. This yield also depends on soil parameters, crop varieties and availability of irrigation.

Fertilizer replacement

Synthetic fertilizers can increase the soil's nutrients more than organic fertilizers. But synthetic fertilizers are able to provide only particular nutrients to the crops. Farmers use synthetic fertilizers to increase crop production immediately that on other hand intense and continuous use of such synthetic fertilizers creates crops that are susceptible to insect attacks, microbial pathogens and intrusive weeds. If only synthetic fertilizers are added to the soil, without organic manure (slurry, FYM and compost) decreases soil productivity and if only organic manure is added, decrease the desired crop yields (Liu et al. 2009). Most of time, optimum crop yield and soil fertility levels can be achieved through the combination of synthetic and organic fertilizers. Synthetic fertilizers are expensive and most small-scale farmers cannot afford them for a long duration. The high costs involved make it essential for most of developing and African countries to find an alternative to synthetic fertilizers (Dahiya et al. 1985). Furthermore, often the bioslurry combined with synthetic fertilizers shows better yields than bioslurry utilization on its own (Groot et al. 2013).

The use of biogas slurry reduces costs, as synthetic fertilizers are no longer necessary and crop production increases. Due to the results of the different studies and taking into account environmental effects and costs of synthetic fertilizers, using around 10 to 15 t/ha of biogas slurry is suggested, starting fertilizing after ploughing and 21 to 28 days before planting. Once the sprouts are above ground biogas slurry application should be done solely by spreading it onto the roots of the plant at noon while mixing it with the soil (Karki, 2001).

However, the economic value of organic fertilizer to a farmer is the value of increase in crop yields and/or crop quality that is derived from its use. The cost benefit ratio will determine the economic aspects of its use (Alam, 2006).

One cubic meter slurry contains 0.16 – 1.05 Kg N which is equivalent to 0.35-2.5 Kg urea (Vinh, 2010).

The nitrogen content of slurry is 1.5% (1.5% N, 1.1% P and 1% K).

From 730 MT dung, 76.8 MT slurry produced per year (only for bovine dung).

In 76.8 MT slurry, nitrogen content is 1.15 MT nitrogen.

1 kg Nitrogen is equivalent to 2.2 kg Urea fertilizer (Urea contains 46 % N).

Cost of urea is Rs. 276/50 kg bag

So cost of 1.15×10^9 kg N will be 13.74×10^9 INR.

As per above estimation, we can say that 76.8 MT slurry effectively reduce import bill by 13.74 billion INR. Mineral fertilizers alone cannot correct all the nutrients deficiency in agricultural soils. The prices of the imported fertilizers will continue to increase in from last few decades. Therefore, transformation of all native organic resources and recycling them into soil fertilization program should be undertaken early as much possible. The use of biogas slurry can reduce the application of synthetic fertilizers to a great extent. It is possible to reduce the use of the synthetic fertilizers up to 15-20%.

Conclusions

Biogas slurry may be considered as a good quality organic fertilizer in sustainable agriculture for maintaining the quality of produce. Biogas slurry has potential to provide a considerable amount of both macro and micro nutrients besides appreciable quantities of organic matter. Along the richness in nutrients it also has very low amount of heavy metals as compared to synthetic fertilizers. Biogas slurry (Dry-DBGS & Wet-DBGS) is environmental friendly, has no toxic or harmful effects and can easily reduce the use of chemical fertilizers up to 15-25%.

Biogas slurry has significant potential to improve the physical and biological quality of soil (improvement in soil structure, improvement in water holding capacity, cation exchange capacity, lesser soil erosion and provision of nutrients to soil micro-flora including nitrogen fixing and phosphorous solubilizing organisms) besides providing both macro and micro-nutrients to crops. Yield increases due to biogas slurry application, have also reported for many crops including field crops, tobacco, castor, peas, mustard, onion, cabbage, banana, chillies, pearl millet and sugarcane. A combination of biogas slurry (Dry-DBGS & Wet-DBGS) and synthetic fertilizer enhanced carbon nitrogen transformation with substantive effect on crop yield. Finally, we come out with conclusion that biogas slurry provide a beneficial way for farmer's community, reduce fertilizer burden on economy of country and improve sustainability of field.

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Conflict of interests

The author(s) declare(s) that they have no conflict of interests.

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