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Studies on the Effect of Urine on Biogas Production

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Abstract

Only 20 % of our rural households in Bangladesh have more than 4 cattle heads and 21 % have more than 2 cattle heads. A 5-8 members family needs 4-6 cattle to run a biogas plant to meet their daily cooking energy. For wide spread dissemination of biogas technology throughout the country it becomes imperative to increase the number of biogas plant users by increasing the gas production rate with the present available cattle heads. It has been found that with the addition of urine to cow-dung gas production has been increased upto 30 % at a proportion of dung, urine and water (50:35:15) which will reduce the number of cattle heads and plant size and hence the construction cost. This will certainly increase the technology users up to 41 % with the present available cattle heads and thereby solve the cooking fuel and organic fertilizer crisis and maintain the hygienic condition.

Introduction

Energy is one of the vivid factor for the human civilization. It is evident from the historical and modern civilization of mankind that our existence is highly dependent on energy. In many developing countries like Bangladesh there is an acute shortage of both conventional and traditional fuels. If we are concerned only about the cooking fuel, the dearth of fuel is more acute because of the alarming depletion of forest resources. To meet the demand of this cooking fuel in Bangladesh, about 39 million tons of fire-wood and other residues are being consumed annually. There is a limited source of oil and a good reserve of 400 billion cubic meter of natural gas in Bangladesh. The consumption of natural gas at different sectors are shown below.

Sectors	% of use
Power generation	44.0
Fertilizer	36.0
Industrial	12.5
Domestic	5.5
Commercial	2.0

There is no use of natural gas in the field of transportation as well as petrochemical production. The Asian Development Bank (ADB) has announced[1] to patronize versatile uses of natural gas. The government is also interested to promote new and versatile uses of natural resources for economic development. Natural gas might become a substitute of petrol in internal combustion engines which can reduce the dependence of imported oil and save a huge amount of foreign exchange. Therefore, it becomes necessary to find out alternative sources of energy. Biogas can play an important role to meet the cooking fuel crisis as well as organic fertilizer problem.

Biogas can be obtained by anaerobic decomposition of any decomposable organic raw materials such as cow dung, poultry excreta, human waste, agricultural residue etc. Biogas contains mainly 60-70 % methane and 30-40 % carbon dioxide. Residue left after gas production is a good organic fertilizer rich in N P K.

A 5-8 members family needs 4-6 cows to run a biogas plant to meet their daily cooking energy. The ownership of cattle heads and household of Bangladesh is shown in Table I.[2]

It is seen in Table I that only 20 % of rural house-holds have more than 4 cattles and 21 % have more than 2 cattle heads. So it becomes essential to increase the number of biogas plant users by increasing gas production rate with the present available cattle heads. The Khadi and Village Industries Commission (KVIC) of India estimates[3] that average gas production rate per kg cow dung is about 0.037m^3. In order to increasing gas production rate from cow dung a considerable research were carried out by some researchers. Literature survey indicates[4-5] that addition of certain substances increases the out put of gas from cow dung. These substances include chemicals, ground nut cake, urine etc. Gas yield has been increased by a factor of 2.14 compared to control by the addition of 30-50 ppm urea to cow dung.[6] Therefore, any available cheap organic raw material rich in nitrogen can be mixed with cattle dung to increase the gas production. Urine may be considered in this regard.

Table I. The ownership of cattle heads and household of the country[2]

Number of cattle per household	Household %	
0.40	59	
2.24	21	
4.40	16	41
6.80 and above	4	

Each cattle discharges sufficient amount of urine everyday which are drained out and practically no use. It also pollutes environment. Cattle and human urine have been analyzed in the laboratory and shown in Table II.

Table II. Cattle and human urine constituents

Constituents	Cattle urine	Human urine
Dry matter, %	0.6	0.4
Water content, %	99.4	99.6
pH	8.6 ~ 9.2	4.8 ~ 7.5

Generally C/N ratio of urine is lower than cow dung i.e urine is rich in nitrogen which may enhance the gas production rate if mixed with cow dung at a certain proportion. pH of cattle urine also favors the gas production in anaerobic process.

Generally cattle dung is deficient in both phosphorous and nitrogen. If urine is added, then protein source increases the nitrogen content of the raw materials, causes fertilizer value to the optimum conditions.

A good quality compost contains[7]

Nitrogen (N_2), % ... ... 1.0 ~ 1.5
Phosphorous (P_2O_5), % ... ... 0.3 ~ 0.4
Potassium (K_2O), % ... ... 1.0 ~ 1.3

And the mixed spent slurry of night soil, urine and dung contains [8]

Nitrogen (N_2), % 2.60
Phosphorous (P_2O_5), % 0.45
Potassium (K_2O), % 0.93

which is higher manurial value of normal compost. As a result with the increasing soil fertility it will increase the crops yield. Moreover, with the use of urine the environmental pollution control will be decreased enormously.

In Sweden,[9] human urine has been tested in the form instead of mineral nitrogen content fertilizer which shown same level of benefits in the plants yield (grain cultivation). Since most of the nitrogen is lost immediately after urine has been spread, it is recommended that it should be composted deep in the field. The spreading of urine in the field makes sense only if the benefit exceeds the costs and the use causes no harm to the environment or health. So it is the time to use urine in the field as fertilizer if it can be treated anaerobically. The financial value of urine is based on the fertilizing effect of its nutrients which are suitable for plants; the use of artificial fertilizer can be reduced also.

Carbon-nitrogen ratio of raw material is an important factor for biogas production. It is commonly recognized that a C/N ratio of 20-30 : 1 is acceptable. The constituents of cattle and human wastes are shown below.[10]

Constituents	Cattle waste	Human waste
Carbon content, %	7.30	2.50
Nitrogen content, %	0.29	0.85
C - N ratio	25:1	3:1

Overall, with the above circumstances, attention has been taken for use of urine in the substrate for fulfilment of the rural energy needs and to enrich the fertilizer value, to increase gas production rate, to reduce plant installation cost and so on. The present investigation is therefores conducted to study the effect of urine on biogas production.

Materials and methods

Cattle dung and urine were collected and mixed with requisite amount of water for maintaining total solid concentration of about 10 % . The pH becomes around 7.0 and C-N ratio 18-25:1. Different proportions of dung, urine and water were taken in aspirator bottles and in another two aspirator bottles one for gas collection and another for displaced water collection connected in series for different experiments shown in figure 1. Seeding materials were added into the raw materials for its rapid fermentation. The daily gas production was recorded and gas analysis was done by ORSAT apparatus. CO_2 and H_2S were removed from daily gas production by using NH_4OH solution. Moisture and ash contents of fresh substrate and fermented

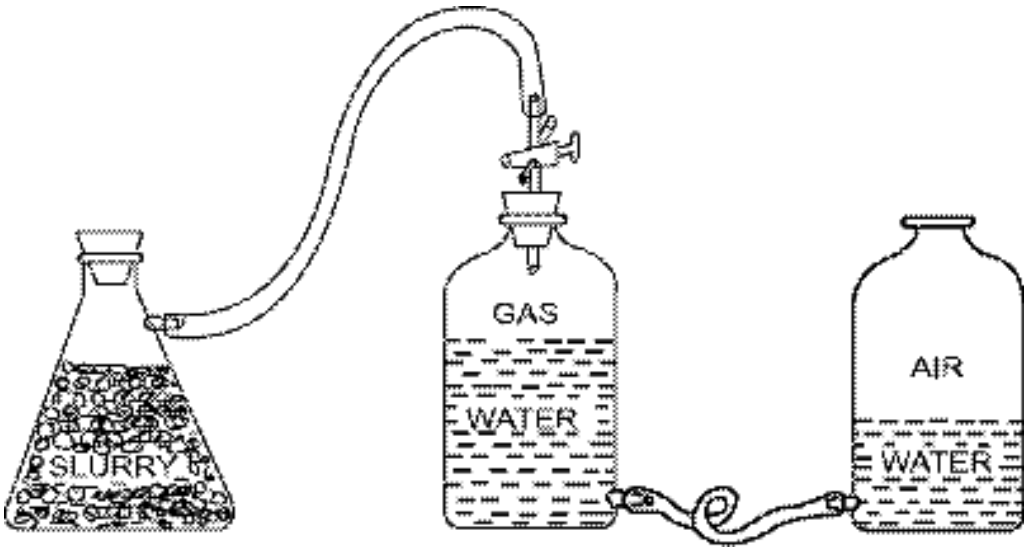

Fig. 1 Experimental setup of bio-gas generation using cow dung and urine

substrate were estimated by gravimetric method by drying at 105^{O} C and by complete combustion at 800^{O} C respectively. Percentage of C, N, H & S were determined by Elemental Analyser (EA-1108, Fisons Instrument, Carloerba, Milon, Italy). The physico-chemical properties of fresh substrate and fermented substrate proper were determined and shown in Table III & IV. The manurial value of fertilizer and composition of biogas obtained from the experiment were analyzed and shown in Table V and VI.

Table III. Physico-chemical properties of fresh substrates

Constituents/ Parameters	Fresh Cow-dung	Fresh Cow-dung with urine
pH	6.9 ~ 7.5	6.9 ~ 7.5
Density, in g/ml (wet basis)	1.05	1.05 ~ 1.20
Ash, in % (air dried basis)	30.5	30.7
Moisture content, in % (wet basis)	83.0	81 ~ 83
Total Solid, in % (wet basis)	17.0	17-19
Total Carbon, in %	38.6 ~ 42.5	38.6 ~ 42.5
Total Nitrogen, in %	1.29 ~ 1.7	1.44
Total Hydrogen, in %	5.50	5.43
C-N ratio	18 ~ 25:1	18~25:1
Sulphur, in %	0.18	0.18

Table IV. Physico-chemical properties of fermented substrates

Constituents	Spent slurry of Cow-dung	Spent slurry of Cow-dung with urine
pH	7.10	6.98
Density, in g/ml (wet basis)	1.05	0.98 ~ 0.99
Ash, in % (air dried basis)	29.00	28.80
Moisture content, in % (wet basis)	90.00	90.00
Total Solid, in % (wet basis)	10.00	10.00
Total Carbon, in %	31.5 ~ 37.5	37.0 ~ 39.2
Total Nitrogen, in %	1.50	1.50
Total Hydrogen, in %	5.20	4.94
C-N ratio	18 ~ 25:1	18~26:1
Sulphur, in %	0.08	0.10

Table V. The manurial properties of fresh and spent substrates

Constituents	Fresh cow-dung	Spent cow-dung	Fresh dung with urine	Spent dung with urine
Nitrogen (N_2), in %	0.75 ~ 1.3	1.5 ~ 1.8	1.8 ~ 1.9	2.3
Potash (K_2O) in %	0.8 ~ 1.2	0.9 ~ 1.7	0.97 ~ 1.4	0.99 ~ 1.65
Phosphorous (P_2O_5), in %	1.6 ~ 2.2	2.3 ~ 2.6	0.41	0.43

Table VI. Gas composition of cow-dung and urine mixed with cow-dung

Constituents	Vol. of gas in % by cow-dung	Vol. of gas in % by cow-dung with urine
Methane (CH_4)	62.5	65.0
Carbon dioxide (CO_2)	34.5	31.8
Carbon monoxide (CO)	0.0	0.0
Oxygen (O_2)	0.3	0.3
Hydrogen Sulphide (H_2S)	0.1	0.1
Hydrogen (H_2)	1.1	1.1
Nitrogen (N_2)	1.5	1.7
Moisture (H_2O)	Trace	Trace

Results and Discussions

The biogas generation with different proportions of urine, dung and water are shown in Table VII and in figure 2. It is seen in Table VII that gas production has been increased upto 30 % at a proportion of 50:35:15 (cow-dung: urine: water) and 10 % at a proportion of 50:5:45. This table also shows that gas production increases with the increase of urine and reaches a maximum and then decreases even with the increase of urine in the substrate. This is, may be due to the excess of Nitrogen in the slurry. From figure 2 it is clearly seen that gas production is higher in case of cow-dung with urine than cow-dung alone. The same quantity of biogas can be obtained from 3-4 cows instead of 5-6 cows if urine is added to cow dung at a certain proportion. With the addition of urine the gas quality i.e % of CH_4 increases which is seen in Table VI. By removal of impurities % of CH_4 can be reached upto 93 % and can be linked to grid also[11] (shown in table VIII). Moreover, during anaerobic process there is no more evolution and loss of N_2 in the atmosphere. So the environmental situation improves the public health also.

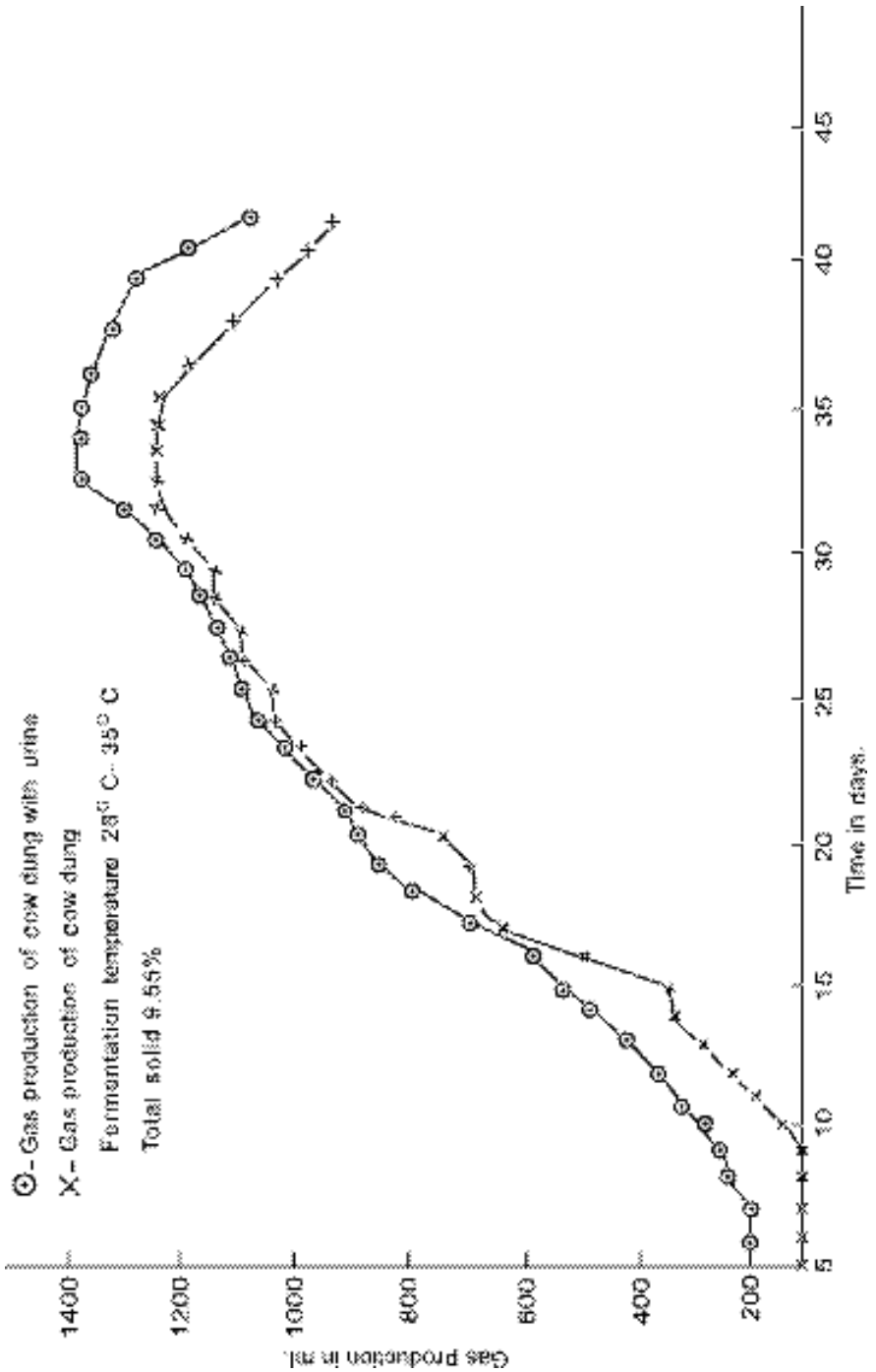

Fig. 2 Daily gas production of cow dung and cow dung with urine.

Table VII. Biogas production with different concentration of dung, urine and water at a temperature 28^{O} C – 35^{O} C for 1kg dung in 2 litres of slurry

Sl. No.	Proportion (cow-dung: urine: water)	Amount of gas yield in liters	Amount of increased gas yield in %
1	50:0:50	36.80	---
2	50:5:45	40.48	10
3	50:10:40	42.32	15
4	50:15:35	44.16	20
5	50:25:25	46.00	25
6	50:35:15	47.84	30
7	50:40:10	46.00	25
8	50:50:0	42.32	15
9	50:100:0	40.48	10
10	50:10:40 (human urine)	43.42	18
11	50:50:0 (human urine)	41.95	14

Table VIII. Biogas production with different concentration of dung, urine and water at a temperature 28^{O} C – 35^{O} C for 1kg dung in 2 litres of slurry

Day	Gas production (in ml.)	CO_2 %	H_2S %	CH_4 %
1	290	36.0	0.20	62.5
2	310	13.0	0.00	86.5
3	350	7.5	0.00	92.0
4	375	4.5	0.00	95.0
5	660	3.1	0.00	96.5
6	900	2.5	0.00	97.0
7	950	2.0	0.00	97.5
8	1250	1.5	0.00	98.0
9	1350	1.0	0.00	98.5
10	1300	0.3	0.00	99.0
11	1040	0.0	0.00	99.5
12	775	0.0	0.00	99.6
13	900	0.5	0.00	99.0
14	750	1.0	0.00	98.6
15	750	2.0	0.00	97.5

To be continue

Table VIII.

Day	Gas production (in ml.)	CO_2 %	H_2S %	CH_4 %
16	730	4.0	0.00	95.4
17	640	7.0	0.05	92.5
18	630	10.0	0.10	88.9
19	600	12.0	0.10	87.0
20	570	13.5	0.10	85.0
21	500	15.0	0.15	84.0

Conclusion

From the above investigation it may be concluded that with the addition of urine to cattle dung gas production has been increased significantly upto 30 % which certainly reduce the number of cattle heads and hence the plant size. Therefore, the construction cost of biogas plant will be decreased accordingly. This research therefore, will accelerate the dissemination programme of bio-gas technology throughout the country.

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