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Potential for Value Addition of Buffalo Dung through Eco-friendly Disposal in India

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Abstract

A study was carried out on value addition of buffalo dung through eco-friendly disposal using anaerobic decomposition and subsequent vermicomposting with the objective of identifying a solid waste management system that is economical to the dairy producers besides protecting the environment. The average dung produced per day by a buffalo weighing 400±50 kg was ranged from 19.05 to 26.75 kg which was significantly (P<0.01) different among buffaloes due to variation in body weight. The average total and volatile solids per cent of the buffalo dung and digested slurry were 20.56 ±0.48 and 9.05± 0.12 and 78.37±0.38 and 67.13± 0.61 per cent, respectively which were significantly (P<0.01) different. The average P^H of the buffalo dung and digested slurry was 7.8±0.04 and 7.9±0.03. The average time (minutes) maintained the lighting and cooking (500g) rice plus lighting was 910.47±0.82 and 708.47±0.53, respectively. Value addition of 50 kg buffalo dung through biogas production and subsequent vermicomposting of digested slurry an amount ₹ 102.0 may be additionally earned compared to traditional open composting of fresh buffalo dung besides protecting the environment.

Keywords: Buffalo dung, value addition, biogas production, vermocomposting.

Introduction

India has 105.3 million buffaloes which constitute 55.7 % of the total world buffalo population. Solid waste being generated from this huge number of buffaloes is a valuable source of nutrients and renewable energy. However, most of the solid waste being produced from these animals in India left to decompose in the manure pits and are exposed to rains as they are not covered[1]. The green house gasses released from open decomposition of manure causing major environmental problems[2]**.** The leaching loss of nutrients, particularly N, not only reduces the quality of manure but also causes pollution in nearby wells and waterways[3]. Therefore, it is essential to develop a new waste management system that makes dairy production operations economically viable to the farmers besides protecting the environment.

Anaerobic digestion of dung helps in manure stabilization, sludge reduction, odour control, and produce biogas which is a good source of non conventional energy. During anaerobic digestion organic substances in the dung converted in to biogas through sequential involvement of different groups of bacteria[4]. Biogas is a methane-rich gas, which is a colourless, blue burning gas that can be used as fuel for cooking, heating, lighting and electricity generation. Therefore, biogas is an alternate energy source, which will decrease the demand of fossil fuels[5]**.** Biogas production in rural villages of India being carried out using two common anaerobic digesters i.e. the "Khadi and Village Industries Commission (KVIC) Floating Dome" model and the "Janata, Fixed Dome" model[6].

The slurry obtained after anaerobic digestion of dung can be directly applied to the agricultural fields as a soil conditioner. However, due to its wateriness, farmers are not showing interest to apply it directly to agricultural fields[7]. Therefore, it is essential to convert the slurry obtained from the biogas plants in to other farms like vermicompost in which earthworms can modify its physical and biochemical properties[7]. Since there is dearth of information on value addition of buffalo dung, the present research has been carried out to study the eco-friendly disposal buffalo solid waste through anaerobic decomposition and vermicomposting.

Materials and methods

Ten Graded Murrah buffaloes were randomly selected from the Instructional Livestock Farm Complex (ILFC), NTR College of Veterinary Science, Gannavaram with an average body weight of 400±50 kg. The buffaloes were stall fed in the shed and offered 20 kg chopped green jowar fodder and 10 kg paddy straw to each buffalo per day to meet the maintenance requirement. Concentrate feed was offered at the time of milking as per the milk production i.e 1 kg concentrate per 2 kg milk production. The dung voided by the buffaloes was collected manually for 24 hours and quantified using weighing balance on weekly basis for a period of 2 months.

Estimation of Total solids in the dung (TS): Samples of 50 grams were used to determine the total solids (TS %) per cent for the fresh dung and digested slurry. The samples were weighed in petri plates and kept in hot air oven at 105^0 c for a

period of 24 hours. The solids remaining after removal of moisture was estimated using following formula[8].

TS % = (Final weight/Initial weight) X 100

Estimation of Volatile Solids (VS): The dried residue obtained from total solid analysis was weighed and heated in crucible for 2hrs at 500^0 C in furnace. After cooling crucible residue was weighed[8].

VS % = [100-(V3-V1/V2-V1)] X 100

Where, V1= Weight of crucible, V2= Weight of dry residue and crucible, V3= Weight of ash and crucible (after cooling)

P^H of the dung and digested slurry: P^H of the dung and digested slurry was measured at weekly intervals. 1gm samples of the dung and digested slurry were mixed with distilled water and the P^H was measured with EU tech P^H meter (ECFC 7252101 BE).

Estimation of biogas gas requirement: The size of the digesters was determined by the cooking and lighting requirement of a family comprising 4 persons. For cooking, the quantity of gas required per person is 0.227 m^3 [9]. The required gas per house hold of 4 persons is 0.908 m^3. For lighting, the quantity of gas required to illuminate a 100 candles lamp (60 watt electric bulb) is 0.125 m^3. For 3 lights the requirement is 1.13 m^3. Therefore, the requirement of biogas to meet the cooking and lighting requirement for a family of 4 persons is 0.908+1.13=2.038. one kg of fresh buffalo dung produces 0.04 m^3 of biogas[10]. To produce approximately 2.0 m^3 biogas, nearly 50 kg of fresh dung will be required.

Estimation of Plant capacity: To estimate digester volume[9], $V_d = V_f X T_r$

Where, V_f = Volume of fluid in the digester, T_r = Hydraulic retention time, V_f = Volume of fluid in the digester = mass/density, 1 kg fresh dung contains 0.18 kg solids and 50 kg dung contains 9.0 kg solids. Therefore, volume of the fluid is 9/50=0.18 m^3 per day. If the hydraulic retention time taken as 30 days (8-50 days[9]), the volume of the digester (V_d) is 0.18X30=5.4 m^3. The actual volume of the digester is 1.1 X V_d. Therefore, the digester volume is 5.94 m^3 i.e. around 6.0 m^3. The digesters were constructed as per the specifications provided by New and Renewable Energy Development Corporation of Andhra Pradesh Ltd., (NREDCAP), and Vijayawada.

Feeding to the Digester: A homogenous mixture was prepared by mixing with equal quantity of water to the buffalo dung i.e 50:50 ratio. The digester was charged with buffalo dung at 8-10 per cent total solids up to 75 per cent of its volume. After stabilization, 50 kg of buffalo dung and 50 liters of water was fed daily at total solid concentration of 8-10 per cent for 60 days. The gas started generating from third week after charging the digester. After 30 days of stabilization, the results were measured for the period of next 30 days.

Cooking and lighting measurement: The quantity of biogas generated from the floating and fixed dome anaerobic digesters was measured in terms of its fuel value for lighting and cooking. The lighting efficiency of the floating and fixed dome anaerobic digesters was measured by the number of minutes a 100 candle lamp illuminated for first 15days. The cooking plus lighting was measured by the time (minutes) taken to cook 500g of rice with one litre of water on separate biogas stove fixed with household burner of 200 liters capacity / hour for the next 15 days of the experiment.

Vermicomposting of digested slurry: About 100 kg digested biogas slurry (equal to 50 kg fresh dung in total solids) was taken from the storage tank and piled on the ground for one week. At approximately 40 per cent TS level 25kg semidried biogas slurry (equal to 50 kg fresh dung) mixed with 5 kg feed residue were used for the preparation of vermicompost. The slurry was mixed with the residual feed material and mixture was spread on a plastic sheet with a thickness of 30 cm and allowed the material to decompose for 3 weeks. In to the cracks developed on the material, about 2000 earthworms belongs to Eisenia fetida species released and water was sprinkled to maintain the moisture about 80 per cent. The material was covered with gunny bags to prevent the evaporation of moisture. After 50 days, the converted vermicompost which is in black granules, light in weight and free from bad odour, recovered after separation of earth worms. The procedure was carried out in triplicate to avoid error.
The fuel value of biogas produced from the digesters was calculated with comparative fuel values of other sources[11] and the prices fuel and vermicompost was taken from the prevailing market prices. Statistical analysis of the data was carried out according to the procedures suggested[12].

Results and Discussion

The mean quantity of dung voided by Graded Murrah buffaloes are presented in Table 1. Significant (P<0.01) difference was observed in the quantity of dung voided by the buffalos. This might be due to variations in the body weight of the buffaloes which might be responsible for difference in dung production. The average quantity of dung voided by the buffalo ranges from 19.35 to 22.kg[13] and cow ranges from 25-30 kg[14] corroborated the present findings.

The average total solids (TS) content of buffalo dung and digested slurry was 20.56 ±0.48 and 9.05± 0.12 per cent, respectively (Table 2 and Figure1). Significant (P<0.01) difference in TS per cent of dung and digested slurry might be due to dilution effect of the dung with water. The TS per cent recorded in the present study was similar to the results reported[15] for buffalo dung (22.3 per cent). Majority of the

biogas plants constructed in India are using cattle/buffalo dung as substrate and operate at 10 per cent TS concentration[16]. It was reported[17] that 9 per cent TS is optimum for biogas production from agricultural wastes. The TS content after dilution should be 5 to 12 per cent for optimum performance of anaerobic digester[18] which was 10.28 TS per cent in the present study. Compared to the diluted fresh buffalo dung (10.28 % TS), the TS content in the digested slurry was reduced to 9.05 per cent. After anaerobic digestion, the total solids content was decreased from 10 to 7 per cent in slurry than in fresh dung[19].

Table -1
Quantity of dung voided per day by the Graded Murrah buffaloes

	Buffalo number									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Dung voided	25.44^{a} ±0.23	26.69^{a} ±0.29	19.05^{b}± 0.30	26.75^{a}± 0.34	26.39^{a}± 0.27	26.63^{a}± 0.41	20.18^{b}± 0.34	$_{26.11}^{a}$± 0.16	$_{26.55}^{a}$ ±0.19	26.2^{a}± 0.18

^{a,b,} values bearing different superscripts in a column differ significantly (P<0.01)

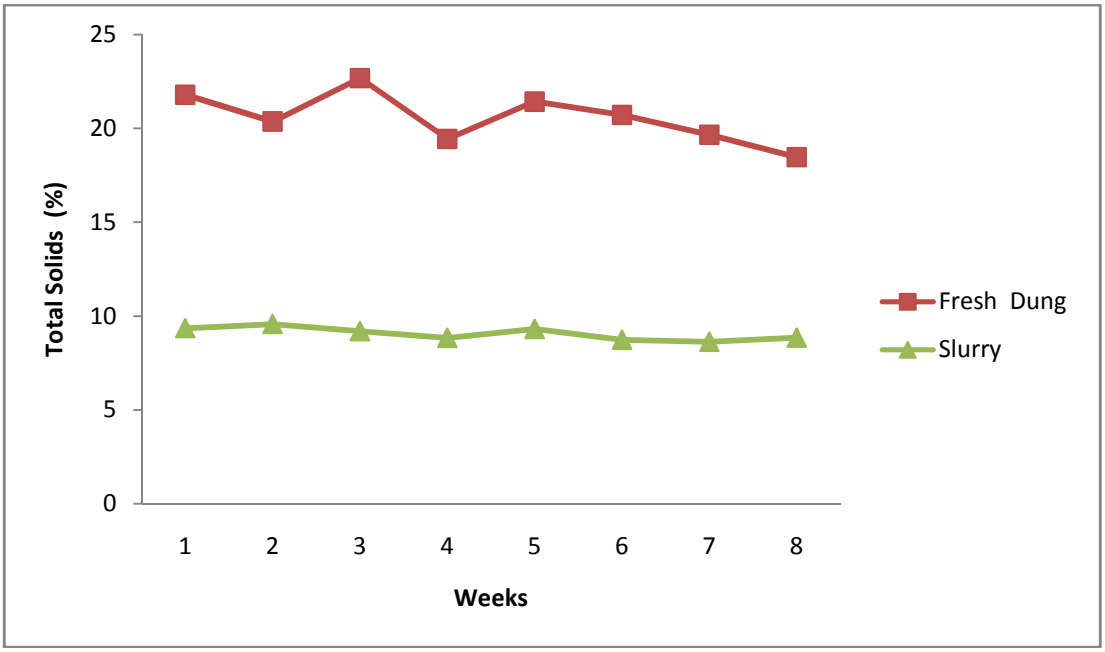
Table- 2
Physical and chemical properties of buffalo dung and digested slurry

Parameter	Dung	Digested slurry
Total solids	20.56^{a} ±0.48	9.05^{b}±0.12
Volatile solids	78.37^{a} ±0.38	67.13^{b} ±0.61
P^{H}	7.8^{a} ±0.04	7.9^{b} ±0.03

^{a,b,} values bearing different superscripts in a column differ significantly (P<0.01)

The mean volatile solids (VS) content of the buffalo dung and digested slurry was 78.37±0.38 and 67.13± 0.61 per cent, respectively (Table 2 and Figure 2). Significant (P<0.01) difference was observed in the VS content of the dung and digested slurry which might be due to dilution effect of the dung with water. The VS content is the total amount of organic matter and is an important indicator for biogas production. The VS content of the fresh cow dung and digested slurry was 78.60 and 60.80 per cent, respectively reported[15] corroborating the present study.

The average P^{H} of the buffalo dung and digested slurry was 7.8±0.04 and 7.9±0.03, respectively (table-2). Significant difference was not observed in P^{H} value of dung and digested slurry. Optimum biogas production is achieved when the P^{H} value of input dung mixture is around 7 to 9 which favours the growth of methanogenic microorganisms[20]. Increase of P^{H} in the cow dung from 7.58 to 7.86 due to anaerobic digestion was reported[19].



Figure–1
Total solids percent of buffalo dung and digested slurry

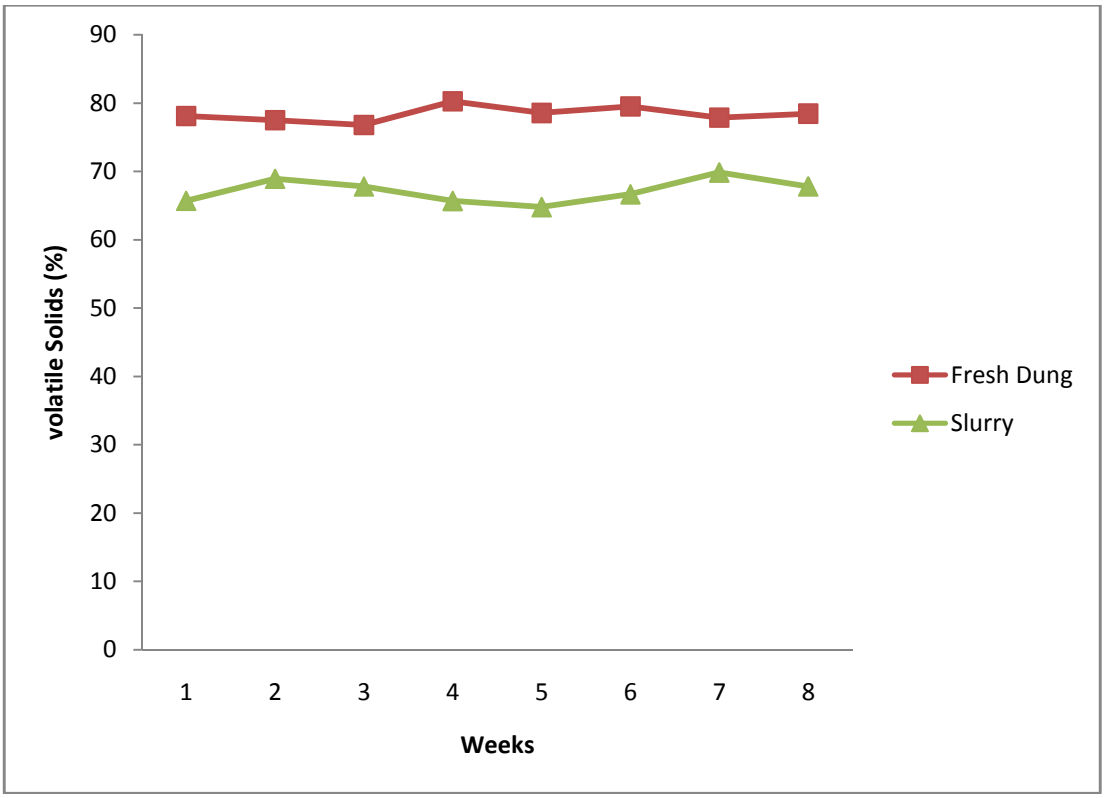


Figure –2
Volatile solids percent of buffalo dung and digested slurry

The average time spent by the dung inside the digester before it comes out is known as the hydraulic retention time (HRT). In the present study, the HRT for the buffalo dung was kept at 30 days. The dung requires HRT at least 10-30 days in mesophilic condition, while in thermophilic environment HRT is shorter[21]. In India, typical HRT of the KVIC floating dome digesters are in the tropical south was 30 days and in the north it was 50-55 days[22].

The average time (minutes) maintained the lighting and cooking 500g rice plus lighting was 910.47±0.82 and 786.33±0.29 per day respectively, by the biogas generated from 50 kg buffalo dung in floating digester (Table 3). The biogas required to light 100 candle lamp (60 watt bulb) is 0.125 m^3 per 60 minutes[10]. Therefore, 1.90 cubic meters of biogas was produced from 50 kg buffalo dung i.e.. 0.038 cubic meters of biogas /kg buffalo dung. One kg buffalo dung produce 0.040 cubic meters of biogas[10] which is close to the output of biogas obtained in the present study.

Table 3
Fuel value of biogas produced from buffalo dung

		Fuel efficiency	
Quantity of dung	**Dilution rate**	**Lighting* (hrs)**	**cooking plus lighting* (hrs)**
50 kg	1:1	910.47 ±0.82	786.33 ±0.29

***** Lighting of 100candle lamp (60 watt bulb), **Cooking 500 g rice plus lighting of 100candle lamp (60 watt bulb)

The TS per cent of the fresh buffalo dung (10.28) was reduced almost to half (9.05) after digestion due to dilution effect with equal quantity of water and 25 kg dried slurry with 40 per cent total solids which was equal to 50 kg fresh dung used for vermicompost preparation. Vermicomposting efficiency of E. fetida earthworms increased when fresh digested biogas slurry mixed with other organic materials like straws[23]. The average quantity of vermicompost obtained in the present study from 25 kg dried slurry and 5 kg residual feed material was 16.3 kg which is 54.33 per cent of the original substrate. Vermicompost output from the cattle dung at moisture content 60% varied from 39-86 % [24] corroborated yield obtained in the present study.

The economic benefit of biogas utilization for cooking and lighting and subsequent vermicompost preparation of the digested slurry was presented in Table 4. The dung based biogas plant is having double benefits as firstly, it provides clean combustion fuel for cooking and secondly, the residual slurry is a good source of bio-fertilizer[25]

The cost of 50 kg buffalo solid waste without value addition at present market price is around ₹ 25/-. However, after value addition of 50 kg buffalo dung through biogas production and subsequent vermicomposting of digested slurry an amount of ₹ 127.00/- can be earned with an additional amount of ₹ 102.0 over conventional disposal of buffalo dung in India. Similar

findings reported[16] that benefit cost ratio of fixed dome type pilot size biogas plant was calculated to be as 1.49:1. Other benefits of biogas plants include decrease in fuel wood consumption for cooking and use of chemical fertilizer in agriculture. Buffalo manure for the production of biogas is beneficial both for the environment and the economy; the former when the gas is used as a vehicle fuel replacing petrol/diesel as well as reducing direct emissions from the manure storage[26] corroborating the present findings.

Table -4
Economic benefit of biogas production and vermicomposting of buffalo dung

Parameter	Without value addition (₹)	After value addition(₹)
Cost of 50 kg raw dung	25	-
Cooking and lighting value of Biogas produced (1.9m^3 in the floating digester)* equal to the cost of 0.99/1.0 litre diesel	-	62.00
Value of Vemicompost 16.3 kg @ Rs 4 per kg		65.00
Total savings		127.00

*15.16 hours lighting of 100candle lamp (60 watt bulb) @ 0.125 m^3 per hour[8]

is equal to 1.9 m^3 biogas. One $m^3$of biogas can save 3.50 kg of wood, 12.30 kg of dung cakes, 1.6 kg of coal, 0.62 litre of kerosene oil, 0.43 kg of LPG and 0.52 litre of diesel[9]

Based on the present study it was concluded that allowing open decomposition of buffalo solid waste not only posing environmental hazards but also cause economic loss to the dairy producers. The present study indicated that anaerobic decomposition of the buffalo dung in floating dome digester and subsequent vermicomposting of the slurry obtained may improve the buffalo production economically viable besides protecting the environment.

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