Partitioning of Animal Feed Nitrogen into Excreted Solid Waste and its Recycled Products

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Article Info

ABSTRACT

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The present study was designed aiming to quantify the daily feed intake and voided amount of adult beef animals and the future potentiality of voided material through following proper recycling methods. An animal trial was arranged to quantify the sum of daily intake and outgo of 10 individual animals separately. Regular dung and urine were collected in a separate bucket and weighed at every 24-hours interval using a digital weighing balance. Laboratory scale anaerobic digestion of solid dung was continued up to 60 days and the total gas and slurry production was quantified. Results showed that about 7.84 kg feed DM and 0.83 kg N were consumed by each animal daily of which 33% of consumed feed volume became lost in solid dung where the excreted DM extent was 25%. In the case of nitrogen, the losing range was 42.2%. 1kg solid dung mixed with an equal amount of water produced 0.03 cubic meter biogas and 1.86 kg bio-slurry from the digestion anaerobically. The gas production trend was somewhat slow in the first week which started to increase up to 4th week. Only 27.78% DM of supplied feedstock was used during gas production and the remaining portion come out from the digester as residue. The DM and N of fresh bio-slurry was 7.0 and 2.31% respectively and the recovered N in the fresh slurry was 100 times higher than fresh dung. The amount of lost feed nitrogen and its future probable potentiality can be defined through this study.

INTRODUCTION

Feeding management claims the largest cash expense in livestock farming but is directly related with the growth, production and health status of an animal. About 70% of total farm costs usually spent in feeding management (Buza et.al. 2014), Makkar (2013) of a farm. But it is a matter of great regret that, a significant share of consumed feed comes out from the body as solid biomass waste or dung. At the same time animal rearing affects the environment negatively by emitting several greenhouse gases (O'mara 2011) through enteric emission and waste production. The contribution of ruminants conceptualizes more by the researchers regarding these aspects compared to others. All the valuable feed nutrients flowed out from body with dung as undigested form. The vital feed nutrient nitrogen is lost in animal excreta as

ammonia (NH₃) which affects the ambience most and it ranges between 10-36% depending on the animal category (Bouwman and Hoek 1995). The rate of feed nutrient loss is comparatively higher in developing countries (Bouwman and Hoek 1995) as animals depend on poor quality fibrous feed here which causes poor digestibility (Zadrazil et al.1995) and a higher degree of gas emission (Mathot et al. 2012). This feed loss represents the economic loss of farmers involved in feed purchasing and its management. So to minimize the environmental deterioration and public health hazard imposed by ruminants and compensate the farmers' financial loss as well, proper and scientific recycling of animal waste should be ensured first to regain the feed nutrients into money or some economic products. In one this approach will secure the long-term sustainability of farm too. It is recognized that, solid animal waste is either stored for a long time without any use or spread in an open space, or preparing burning fuel. Both of the management system is hazardous to public health and environment due to releasing ammonia, nitrous oxide and methane. Whereas this waste is a valuable resource for soil having quality fertilizer

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value in terms of macro and micro nutrients (Lazcano et al. 2008) which is being used by our ancestors in a very sporadic way. But it could be a very good alternative of synthetic fertilizer which one is also threatening the environmental cleanliness through releasing a significant amount of ammonia and other gaseous component. Composting, vermicomposting, and biogas is world-recognized animal waste recycling method among which biogas technology is growing popular now. Along with producing clean biofuel it also produces an organic residual byproduct called bio-slurry. Bio-slurry is an excellent source of soil required nutrients in plant available form without having any toxic compound in it. This system ensures the maximum utilization of animal waste and returns the highest benefit in terms of a clean environment and profitable economy. To quantify the potentiality of animal waste recycling it is essential to know first that, how much dung is produced by an animal daily and how much gas and slurry could be produced from there. Concerning this issue and being a livestock concentrated member of developing countries, the present study was designed to know the extent of feed nutrient loss per day per cow and how much of it could be recovered in using anaerobic digestion system of managing it.

MATERIALS AND METHODS

The experiment was conducted through two approaches viz. field and laboratory study. The field work was carried out at Pachutia Cattle Research Farm of Bangladesh Livestock Research Institution (BLRI) and Biotechnology laboratory of the same institution was used for laboratory study. Total experimental layout is presented in Figure 1.

Figure 1. Layout of the experimental procedure

Animal trial to quantify the daily intake and outgo

Total 10 adult bull of BLRI Cattle Breed-1 (BCB-1) with average initial age of 24 months and 250 ± 1.09 kg body weight were selected and supplied to quantified amount of ration required for each animal separately. Animals were fed a diet composed of fresh chopped German grass as roughage (@ 6kg grass per 100 kg body weight) having 2.60% nitrogen (N) and mixed concentrate (@ 1.25 kg per 100 kg body weight) of 3.06% N. The concentrate mixture was unified with crushed wheat (10%), wheat bran (40%), khesari bran (24%), soyabean meal (21.5%), salt (0.5%), DCP (2%), limestone powder (1%), crushed oyster shell (1%) and vitamin mineral premix (0.1%). Data on the daily feed intake, refusal, dung and urine production was recorded using digital weighing balance. Two plastic made properly marked buckets were allocated for each animal to store the daily produced dung and urine. After 24 hours each bucket was weighed properly to quantify the daily produced dung and urine amount. Samples of fresh roughage, concentrate was collected at certain interval and analyzed for proximate components. Samples of daily feces was collected and three composite sample of each 7 days dung was analyzed at the laboratory. Samples of urine was collected and prepared for nitrogen analysis during the last three days of trial. The total trial was executed up to one month.

Recycling of solid dung through anaerobic digestion system

To quantify the by-pass feed nutrient extent during anaerobic digestion of solid biomass waste obtained from animals belonging to the trial, the laboratory scale biogas digester of biotechnology division was used. To perform this activity, total three digesters was taken, checked and marked properly. Then each digester was sealed with black schoestape. Each digester was filled with 1kg fresh solid dung mixed with equal amount of water, and the lid was closed. A plastic syringe of 60 ml was connected with each digester to quantify the daily gas production amount, and data was recorded. After 60 days, when the rate of gas production decreased then the digester was opened and amount of total produced bio-slurry was measured by digital balance. Fresh sample of bio-slurry was taken to the laboratory to analyze its proximate component composition in both fresh and dry condition. All the chemical analysis was performed at animal nutrition laboratory of BLRI. Data originated from both of the activities were inserted in Microsoft Excel Sheet and statistically analyzed using SPSS statistical software program 17.0 (SPSS Inc., Chicago, IL, USA) where values were expressed as the mean $\pm$ standard error of mean.

RESULTS AND DISCUSSION

Quantification of daily intake and outgo:

Table 1. Daily intake and outgo of feed nutrients (kg day⁻¹)

Intake (Mean±SEM)				Outgo (Mean±SEM)			
Feed (Kg)		Nutrients (Kg)		Amount (Kg)		Nutrients (Kg)	
Roughage	Concentrate	DM	N	Dung	Urine	DM	N
28.45±1.2	3.57±0.1	7.84±0.2	0.83±0.0	10.43±0.3	10.05±0.4	1.91±0.7	0.34±0.0

Data presented in Table 1 shows that, an adult beef animal received 7.84 kg DM and 0.83 kg Nitrogen (N) per day consuming 28.45 kg roughage and 3.57 kg concentrate. In return, they voided 10.43 kg solid dung and 10.05 L urine through which 1.91 kg ingested DM and 0.33 kg N gets out of the body. Literally, the dietary nutrients which state in unused and undigested condition are excreted as urine and feces separately (Dijkstra et al. 2011b), (Hristov and Jouany 2005), Tamminga (1992). Findings of present study illustrate that, the daily extravagance rate of ingested DM and N for each beef animal was about 25 and 42.2% respectively.

This inference supports the statement of Zhao (2019) who reported that the utilization rate of dietary crude protein (CP) or Nitrogen in cattle is very low and slower degradation activity of rumen microbes may be the possible reason behind this. Another relevant study of Oenema (2006) expressed that; the nitrogen utilization efficiency of livestock ranges between 5-45% based on the type of animal and their management system. From here it can be said that a huge number of valuable feed nutrient getting wasted every day and affecting farmers' economy by pushing up the feed cost and environment as well. Tamminga (2003) said, the soluble and gaseous compounds come from livestock production either directly or indirectly affect the environment negatively. Animal metabolism and fecal excretion represent the direct emission (Dijkstra et al. 2011a), Tamminga (1992) and the affecting the environment through releasing methane and nitrous oxide (IPCC 2007) in nature. So, to minimize the environmental deterioration and promote the farm economy appropriate utilization of animal waste must be ensured first. It also assures the long-term farm sustainability too (Nasiru et al. 2014).

Anaerobic digestion cow dung and quantification of bio-slurry production

Composting (Hao et al. 2001, 2004), vermicomposting (Loh et al. 2005), (Gutiérrez-Miceli et al. 2008) and biogas production (Amon et al. 2007), (Masse et al. 2011) are most common and globally recognized scientific method of proper animal waste management. Anaerobic digestion or biogas was preferred management manner in this

study as it is fast growing and most popular animal waste management system of Bangladesh. Maximum priority was given to quantify the amount of bio-slurry production and its nutritional composition. Findings from this study showed that, total 0.03 cubic meter biogas and 1.86 kg bio-slurry was produced from per kg cow dung during the 60 days of digestion period. It is close to the findings of Vishwanath (2016) who reported that 1kg fresh cow dung produce 0.04 cubic meter biogas. The research findings of Khasristya (2014) and Lusk (1998) noted that biogas production depended on several factors like digester size and type, nutrients of feed stock, ratio of C/N, etc. The cumulative gas production volume trend is presented in figure 2 and data shows that, motion of biogas production was somewhat tardy in the 1st week and was in increasing trend with the consecutive advancement of fermentation period up to 4th week. After completion of 4th week it was started to decline and from 6th to last week of trial period it reached to a static rate of production. Only 27.78% DM of supplied feed stock utilized during gas production and remaining 72.22% left in the tank with water as undigested residue namely bio-slurry.

The DM content of fresh bio-slurry was only 7.0% (Table 2) and this finding highly supports the statement of (Kumar et al. 2015). The extent of N% was higher in fresh bio-slurry (2.31%) compared to feed stock cow dung (2.21%). Bio-slurry act as a supreme organic fertilizer (KefaleWagaw 2015) containing significant sum of macro and micro nutrients (Sharma et al. 2016) readily available for plants (Sandeep et al. 2015). So, there is an unprecedented opportunity to uncover new

Figure 2. Cumulative Biogas Production Curve (ml week⁻¹)

Table 2. Nitrogen% of fresh dung and bio-slurry (on DM Basis)

Category	DM	N
Fresh dung	18.39	2.21
Fresh Bio-slurry	7.0	2.31
Dried Bio-slurry	52.16	2.09

possibilities in agricultural farming through the appropriate use of this valuable resource. At the same time, it will mitigate the feed loss in terms of both nutrient and cost in addition to protecting the environment from contamination.

Partitioning of DM and N of 1 kg feed in animal body, their voided share and recycling output:

Considering the findings of present study, it can be calculated that, an animal belonging the trial received 0.32kg DM and 0.03 Kg nitrogen from per kg feed and excreted 33% of feed intake as solid biomass waste (Figure 3). With this outcome they waste 18% and 23% of their received DM and N respectively which simultaneously affect the economy of farmers and cleanliness of the environment as well. If proper utilization of this animal waste can't be ensured, then every year 0.96 kg methane will be released to the environment from an animal when the excreta kept in solid storage condition and the amount will be 1.28 kg/head/year when it is used for preparing burning fuel (Huque et al. 2017). To turn this loss into assets, it is necessary to ensure the improved management mode of livestock waste. Biogas is a most familiar method in Bangladesh regarding this aspect. But bio-slurry management is a big deal there. Farmers can't utilize it due to its physical structure (about 90-93% water) and huge volume of production at a time. When the solid cow-dung obtained from 1 kg feed (0.33Kg) mixed with equal amount of water then about 0.615 gm fresh bio-slurry (Figure 3) was produced after complete fermentation and gas production. About 33.3% DM

of the given feed stock utilized during gas production and remaining amount come out as residue. In case of nitrogen, it was increased about 42.85% in slurry compared to feed stock dung. So, a huge opportunity is there to utilize animal waste for fulfilling the shortage of our soil organic matter and produce more quality food to mitigate the load of food-energy crisis of us.

CONCLUSIONS

Quantification of actual lost amount from supplied feed nitrogen and its probable economic further using technique determination was the major hypothesis of this study. In conclusion it can be said that, naturally a remarkable amount of consumed feed particle and nutrient is being lost by ruminant as waste or dung where nitrogen occupies the peak position (42.2%). But following an appropriate recycling method much of it can be regained into valuable product which also adjuvants to keep the neatness of the surroundings. Biogas technology can play an important role there for Bangladeshi farmers due to having a suitable environment for maintaining anaerobic digestion principles. Being a livestock concentrated country Bangladesh is much potent to incorporate her agricultural agronomic practice by serving most valued organic substances for soil. Because soil organic matter of Bangladesh is declining at an alarming rate due to unplanned and multifarious utilization of it. Using of synthetic fertilizer is also responsible for this alarming situation. So, using livestock manure as soil fertilizer either directly or in processed bio-slurry form could be good solution to tackle this awful situation of agricultural land of us and saving the financial loss of livestock farmers as well.

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Fig-3: Nutrient distribution of 1 kg feed from intake to bio-slurry

Figure 3. Nutrient distribution of one kilogram feed from intake to bio-slurry

Jobaida Shovna Khanam. Md. Tarekul Islam was involved in monitoring the field trial and data collection. The laboratory work was fully conducted by Jobaida shovna khanam. She also prepared the draft manuscript. All the authors acknowledge the great contribution of all the worker involved in the trial conduction both at field and laboratory.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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REFERENCES

- Amon T. Amon B. Kryvoruchko V. Zollitsch W. Mayer K. Gruber L. (2007) Biogas production from maize and dairy cattle manure influence of biomass composition on the methane yield. *Agriculture Ecosystem and Environment*, 118(1–4): 173–182.
- Bouwman A. F. Hoek W.V.D. (1997) Scenarios of animal waste production and fertilizer use and associated ammonia emission for the developing countries. *Atmospheric Environment*, 31(24): 4095-4102.
- Buza M.H. Holden L.A. White R.A. Ishler V.A. (2014) Evaluating the Effect of Ration Composition on Income over Feed Cost and Milk Yield. *Journal of Dairy Science*, 97 (5): 3073-80.
- Dijkstra J. France J. Ellis J.L. Kebreab E. López S. Reijs J.W. Bannink A. (2011a) Effects of nutritional strategies on simulated nitrogen excretion and methane emission in dairy cattle. Wageningen Academic Publishers, The Netherlands.
- Dijkstra J. Oenema O. Bannink A. (2011b) Dietary strategies to reducing N excretion from cattle: implications for methane emissions. *Current Opinion in Environmental Sustainability*, 3(5): 414–422.
- Gutiérrez-Miceli F.A. Moguel-Zamudio B. Abud-Archila M. Gutiérrez-Oliva V.F. Dendooven L. (2008) Sheep manure vermicompost supplemented with a native diazotrophic bacteria and mycorrhizas for maize cultivation. *Bioresource Technology*, 99(15): 7020–7026.
- Hao X. Chang C. Larney F.J. (2004) Carbon, nitrogen balances and greenhouse gas emission during cattle feedlot manure composting. *Journal of Environmental Quality*, 33(1): 37–44.
- Hao X. Chang C. Larney F.J. Travis G.R. (2001) Greenhouse gas emissions during cattle feedlot manure composting. *Journal of Environmental Quality*, 30(2): 376–386.
- Hristov A.N. Jouany J.P. (2005) Factors affecting the efficiency of nitrogen utilization in the rumen. CABI Publishing, Cambridge.
- Huque K.S. Khanam J.S. Amanullah S.M. Huda N. Bashar M.K. Vellinga T. Fielding M. Hicks K. (2017) Study on Existing Livestock Manure Management Practices in. *Current Journal of Applied Science and Technology*, 22(2): 1-10
- IPCC. (2007) Climate Change (2007) Impacts, Adaptation and Vulnerability. Summary for policy makers (Intergovernmental Panel on Climate Change).
- Kefale W. (2016) Characterization and utilization of bioslurry from anaerobic digester for fertilizer in crop production. *Journal of Fertilizers & Pesticides*, 7(2): 1-5.
- Khasristya A. (2004) Rancang Bangun dan Uji Kinerja Biodigester Plastik Polyethylene Skala Kecil (Studi Kasus Ds. Cidatar Kec. Cisurupan, Kab. garut), Tugas Akhir, Fakultas Pertanian, UNPAD, Indonesia.
- Kumar S. Lal C.M. Mahesh K.M. Shakeel A.K. (2015) Biogas slurry: source of nutrients for eco-friendly agriculture. *International Journal of Extensive Research*, 2: 42-46
- Kumar S. Malav L.C. Malav M.K. Khan S.A. (2015) Biogas Slurry: Source of Nutrients for Eco-friendly Agriculture. *International Journal of Extensive Research*, 2: 42-46
- Lazcano C. Gómez-Brando'n M. Domínguez J. (2008) Comparison of the effectiveness of composting and vermicomposting for the biological stabilization of cattle manure. *Chemosphere*, 72(7): 1013–1019.
- Loh T.C. Lee Y.C. Liang J.B. Tan D. (2005) Vermicomposting of cattle and goat manures by *Eisenia foetida* and their growth and reproduction performance. *Bioresource Technology*, 96(1): 111–114.
- Lush Philip D. (1998) Methane Recovery from Animal Manures The Current Opportunities Casebook. NREL/SR-580-25145.
- Makkar H.P.S. (2013) Towards Sustainable Animal Diets, In *Optimization of Feed Use Efficiency in Ruminant Production Systems*. FAO and Asian-Australasian Association of Animal Production Societies, 67-74.

- Masse´ D.I. Talbot G. Gilbert Y. (2011) On farm biogas production: a method to reduce GHG emissions and develop more sustainable livestock operations. *Animal Feed Science and Technology*, 166 (167): 436–445.
- Mathot M. Decruyenaere V. Stilmant D. Lambert R. (2012) Effect of cattle diet and manure storage conditions on carbon dioxide, methane and nitrous oxide emissions from tie-stall barns and stored solid manure. *Agriculture Ecosystem and Environment*, 148: 134–144.
- Meenakshi S. Prashant K.T. Neeru G. Vikas J. (2016) The unrealized nutritive potential of biogas spent slurry for organic farming. *International Journal of Advanced Technology in Engineering and Science*, 4(9): 357-362.
- Oenema O. (2006) Nitrogen budgets and losses in livestock systems. *Int Congr Ser.*, 1293: 262–271.
- Tamminga S. (1992) Nutrition management of dairy cows as a contribution to pollution control. *Journal of Dairy Science*, 75(1): 345–357.
- Tamminga S. (2003) Pollution due to nutrient losses and its control in European animal production. *Livestock Production Science*, 84(2): 101–111.
- Vishwanath J. (2016) Master of Technology, Renewable Energy.
- Zadrazil F. Puniya A.K. Singh K. (2005) Biological upgrading of feed and feed components. In: *Biotechnology in animal feeds and animal feeding*. Wiley-VCH Verlag GmbH., 55–70.
- Zhao G. (2019) Improving Feed Protein Utilization Rate in Cattle through Nutritional Approaches. *Current Protein and Peptide Science*, 20(2): 164-171.