Estimation of total methane emission from enteric fermentation of ruminant livestock in Bangladesh

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**Abstract:** Ruminant livestock is one of the key elements for the agriculture-based economy of Bangladesh, although these animals are often condemned as a source greenhouse gas especially methane (CH\(_4\)). Total methane emission from the enteric fermentation of ruminants in Bangladesh considering Gazipur, Tangail and Mymensingh district is reflected in the output of the present study. The emission was measured using the dry matter intake (DMI) approach based on the total population of ruminants. Feed intake was recorded from on-farm observation and/or farmers records. It was observed that the ration supplied to bovines consisted of 50-60% green roughage, 31-41% rice straw, and 4-10% concentrate mixture. In terms of DMI rice straw has been contributed the highest (51-65%) proportions followed by green forage (24-31%) and concentrate mixture (7-17%). In small ruminant ration, 90-95% feed (DMI 75-86%) was supplied from green grasses and remaining from concentrate mixtures. Although buffalo individually irrespective of sex and age emitted highest amount of methane followed crossbred and indigenous cattle, goat and sheep, the males produced a higher amount of methane than those of female in all species. Total methane emission in Gazipur, Tangail, and Mymensingh districts were 13359.15, 13250.65 and 13653.75 Kg/day and 4876.11, 4836.50 and 4983.62 '000' Kg/year, respectively. In total 848,320 Kg/day and 309,630 '000' Kg/year methane was measured to be emitted in Bangladesh by 56.33 million ruminant livestock where 64.79% had come from indigenous cattle followed by crossbred cattle (20.82%), Goat (8.79%), Buffalo (5.17%) and sheep (0.43%).

**Keywords:** ruminant; methane (CH\(_4\)); livestock; dry matter intake (DMI)

1. **Introduction**
Livestock is an integral part of agriculture and likely to be one of the most important instruments for the economic growth and development of Bangladesh. There are about 23.27 million cattle (4.19 million crossbred and 19.08 million indigenous), 0.83 million buffaloes, 30.33 million goats and 1.9 million sheep in Bangladesh which are essentially integrated with its agriculture as well as socioeconomic system (Banglapedia, 2014). The livestock sector contributes about 2.79% of total gross domestic products (GDP) which is almost 17.15% in total agricultural shares (Hoque *et al.*, 2011; 2016). Nevertheless, about 44% of the total human consumable animal protein comes from livestock sources. Moreover, 4.31% of the total foreign currency comes from the export of livestock originated processed leather and leather goods (Bostami *et al.*, 2015). Besides the use of power
tillers and tractors in crop cultivation, 30 percent of the total tillage is operated by livestock. Furthermore, about 20 percent of the total human population is directly and 50 percent is partially dependent on livestock sector (DLS, 2016). Despite the contribution, livestock, particularly the ruminants are one of the important sources of methane emission on a global scale. According to Singhal et al. (2005), the enteric fermentation of livestock contributes the highest proportion (59%) of greenhouse gas (GHG) emitted from agriculture followed by rice cultivation (23%), manure management (5%), burning of agricultural crop residue (1%) and soils (12%). However, the anaerobic rumen acts as the storehouse of feeds as well as a fermentation chamber in the ruminant stomach. Fermentation of carbohydrates generates free hydrogen, which is utilized by the methanogenic bacteria (like *Methanobrevibacter ruminantium* and *Methanomicrobium mobile*) in order to reduce carbon dioxide and emits methane (Singh and Mohini, 1999). The bacteria in the rumen and the methanogens with their symbiotic association increase the digestion and total microbial production. In general, about 8-12% loss of total dietary energy occurs due to the formation of methane (Blaxter, 1965). Methane production in ruminants depends on the quality, quantity, and digestibility of feed as well as the type of animal concerned. They are capable of utilizing lower quality forages and crop residues, especially rice straw and weeds from cropland. These low-quality feeds incur low digestibility and significantly contribute to producing high quantities of methane. Various attempts have been made to estimate the methane emission from livestock in India (Mohini and Singh, 2001; Garg and Shukla, 2002; Gupta, 2003), in Australia (Kurihara et al., 1999), in New Zealand (Lassey, 2007), USA (Johnson and Johnson, 1995) and so on. Although a study on estimation of greenhouse gas emission from the livestock sector of Bangladesh was conducted (Jahan and Azad, 2013), the contribution of ruminants to the total production of methane in Bangladesh is not measured completely. Therefore, it is important to focus on the emission of methane by enteric fermentation of the ruminants in Bangladesh. It is also important for the better management of agricultural inputs. Keeping the aforesaid reality in mind the present study was attempted to estimate the total methane emission from different categories of ruminant animals (Cattle, Buffalo, Goat, and Sheep) fed on different types of feeds in Gazipur, Mymensingh, Tangail District as well as Bangladesh.

2. Materials and Methods

The body weight, feed intake, DMI, and methane production of different animal are solely dependent on sex, age, breed, variety, feedstuffs, feeding management, etc. The feeding management and availability of feeds vary among different areas. Dairy animals are generally fed at a higher plane of nutrition than non-dairy animals. Only 70% of the total population of young animals of cattle and buffaloes (in the age group of 0.5-1.0yr) was considered for methane emission, as methane is not produced in young calves (0-3 months) due to the non-functioning other men. Kids and lambs (0-2 months old) were also taken as non-methane producing animals. However, the total population of other categories of livestock was taken for methane estimation.

2.1. Identification and categorization of livestock species

Different types of the animal were categorized according to species; age and type of productivity are summarized in the Table 1.

2.2. Estimation of livestock population

The total number of animals in the different category was recorded from the Upazila Livestock Officer (ULO) and District Livestock Officer’s (DLO) office of the respective district. The livestock population of Bangladesh was cited from DLS official website (DLS, 2016), Banglapedia (2014) and Bangladesh Bureau of Statistics (BBS, 2013).

2.3. Estimation of live weight

Live weight of different categories of animals in the selected areas was estimated at farmer’s house using Sheaffer’s formula (Khan et al., 2003) as Live weight (lbs) = GxL/300, where, G= Heart girth (inch) and L= length of animals (inch). The weight in lbs was converted into kg dividing by a factor 2.22.

2.4. Estimation of dry matter intake (DMI)

Feed intake in terms of Kg DMI/head/day was estimated. Initially, the fresh feed intake (Kg) was estimated by surveying directly from farmer’s house of selected areas. The DMI will be calculated using the data according to Ranjan (1997) and Jain et al. (1996) considering the DM (%) of straw, green forage and concentrate mixture are 85, 28 and 85, respectively.
2.5. Estimation of methane emission

Methane conversion factor recorded in numerous feeding experiments, conducted in different laboratories will be taken into consideration. The average value of methane conversion factor [in g CH₄/(kg DMI/100 Kg live weight)] for a particular category of the animal was utilized for the calculation of total methane emission from that category of livestock. The methane emission factors (MCF) for all calves, bull calf, bull and bullock of crossbred cattle along with both male and female buffalo of different age categories (18.4) were taken from Srivastova and Gurg (2002). For heifer calf, milking cow and dry cow of crossbred cattle the MCF (19.26) was taken from Singh (1999). The MCF for all categories of indigenous cattle (16.60) and goat (18.00) were used from ATI (2000). For sheep, the MCF (13.04) was elucidated from Haque and Bhar (2001). Using the MCF for different categories of livestock, the CH₄ emission (g CH₄/Day and Kg CH₄/Year) was estimated.

2.6. Data analysis

The data generated from this experiment will be entered in Microsoft Excel worksheet, organized and processed for further analysis. The analysis was performed using statistical analysis system (SAS, 2010).

3. Results and Discussion

3.1. Livestock population in selected districts and Bangladesh

Data on the population of different categories of livestock collected from different sources were summarized in Table 2. It was observed that the total number of crossbred cattle, indigenous cattle, buffalo, goat and sheep in Gazipur district were 65984, 300473, 13071, 477638 and 29921, respectively; in Tangail district were 65449, 298032, 12965, 473759 and 29678, respectively; in Mymensingh district were 67439, 307098, 13359, 488170 and 30581, respectively. There is a total of 56.33 million ruminant livestock in Bangladesh which accounts for 19.08 million indigenous cattle, 4.19 million crossbreed cattle, 0.83 million Buffalo, 30.33 million Goat and 1.90 million sheep.

3.2. Estimation of live weight and dry matter intake (DMI)

Estimated live weight (Kg) of different categories of animals is summarized in Table 3. The fresh feed intake and DMI are compiled in Figures 1 and 2. For estimating DMI the fresh feed intake (Kg) was measured by surveying directly from farmer’s house. Here, emphasis will be given to the availability of feed rather than the requirement of the animals, as methane is produced from the feed consumed during the course of its digestion. It was observed that green forages comprise about 50-60% of the total feed supplied to large bovines (cattle and buffalo) followed by rice straw (31-41%) and concentrate mixture (4-10%) (Figure 1). In terms of DMI, it was observed that rice straw contributed highest amount (51-65%) followed by green forage (24-31%) and concentrate mixture (7-17%) (Figure 2). In the case of goat and sheep, it was observed that about 90-95% feed had come from green fodder and the remaining from concentrate mixture (Figure 1). In terms of DMI, green grasses contributed about 75-86% of total DMI (Figure 2). The results of some study on feed intake and DMI (Hossain et al., 2003; Baset et al., 2010) were also in accordance with our findings.

Table 1. Categorization of livestock species.

| Male | Cattle (Crossbred and indigenous) | Male | Buffalo | Male | Sheep |
|------|----------------------------------|------|---------|------|-------|
| Calf (<1.0 yr) | Calf (<1.0 yr) | Calf (<1.0 yr) | Calf (<1.0 yr) |
| Bull calves (1-2yrs) | Heifer calves (1-2yrs) | Bull calves (1-2yrs) | Heifer calves (1-2yrs) |
| Breeding bull | Milking cows | Breeding bull | Milking cows |
| Bullocks | Dry cows | Bullocks | Dry cows |
| Goat | | | |
| Kid (<1 yr) | Kid (<1 yr) | Lamb (<1 yr) | Lamb (<1 yr) |
| Buck (1-3 yrs) | Doe (1-3 yrs) | Ram (1-3 yrs) | Ewe (1-3 yrs) |
Table 2. Livestock population of different categories in selected districts and Bangladesh.

| Species       | Sex     | Age/Type                     | Bangladesh (Million) | Gazipur (No.) | Tangail (No.) | Mymensingh (No.) |
|---------------|---------|------------------------------|----------------------|---------------|---------------|------------------|
| Cattle        | Male    | Calf (<1.0 yr)               | 0.39                 | 6142          | 6092          | 6277             |
|               |         | Bull calves (1-2 yrs)        | 0.34                 | 5354          | 5311          | 5472             |
|               |         | Breeding bull                | 0.29                 | 4567          | 4530          | 4668             |
|               |         | Bullocks                     | 0.85                 | 13386         | 13277         | 13681            |
|               |         | Total                         | 1.87                 | 29449         | 29210         | 30098            |
|               | Female  | Calf (<1.0 yr)               | 0.41                 | 6457          | 6404          | 6599             |
|               |         | Heifer calves (1-2 yrs)      | 0.37                 | 5827          | 5779          | 5955             |
|               |         | Milking cows                 | 0.81                 | 12756         | 12652         | 13037            |
|               |         | Dry cows                     | 0.73                 | 11496         | 11403         | 11750            |
|               |         | Total                         | 2.32                 | 36535         | 36239         | 37341            |
|               |         | Cattle (Indigenous)          |                      |               |               |                  |
|               | Male    | Calf (<1.0 yr)               | 2.11                 | 33228         | 32958         | 33961            |
|               |         | Bull calves (1-2 yrs)        | 1.6                  | 25197         | 24992         | 25752            |
|               |         | Breeding bull                | 0.89                 | 14016         | 13902         | 14325            |
|               |         | Bullocks                     | 3.85                 | 60630         | 60137         | 61967            |
|               |         | Total                         | 8.45                 | 133071        | 131990        | 136005           |
|               | Female  | Calf (<1.0 yr)               | 2.18                 | 34331         | 34052         | 35088            |
|               |         | Heifer calves (1-2 yrs)      | 1.74                 | 27402         | 27179         | 28006            |
|               |         | Milking cows                 | 4.32                 | 68031         | 67479         | 69532            |
|               |         | Dry cows                     | 2.39                 | 37638         | 37332         | 38468            |
|               |         | Total                         | 10.63                | 167402        | 166042        | 171093           |
|               |         | Buffalo                       |                      |               |               |                  |
|               | Male    | Calf (<1.0 yr)               | 0.09                 | 1417          | 1406          | 1449             |
|               |         | Bull calves (1-2 yrs)        | 0.07                 | 1102          | 1093          | 1127             |
|               |         | Breeding bull                | 0.03                 | 472           | 469           | 483              |
|               |         | Bullocks                      | 0.05                 | 787           | 781           | 805              |
|               |         | Total                         | 0.24                 | 3780          | 3749          | 3863             |
|               | Female  | Calf (<1.0 yr)               | 0.11                 | 1732          | 1718          | 1770             |
|               |         | Heifer calves (1-2 yrs)      | 0.09                 | 1417          | 1406          | 1449             |
|               |         | Milking cows                 | 0.21                 | 3307          | 3280          | 3380             |
|               |         | Dry cows                     | 0.18                 | 2835          | 2812          | 2897             |
|               |         | Total                         | 0.59                 | 9291          | 9216          | 9496             |
|               |         | Goat                          |                      |               |               |                  |
|               | Male    | Kid (<1 yr)                   | 4.56                 | 71811         | 71228         | 73394            |
|               |         | Buck (1-2 yrs)                | 3.57                 | 56220         | 55764         | 57460            |
|               |         | Buck (>2 yrs)                 | 4.03                 | 63465         | 62949         | 64864            |
|               |         | Total                         | 12.16                | 191496        | 189941        | 195719           |
|               | Female  | Kid (<1 yr)                   | 4.86                 | 76535         | 75914         | 78223            |
|               |         | Doe (1-2 yrs)                 | 3.87                 | 60945         | 60450         | 62289            |
|               |         | Doe (>2 yrs)                  | 9.44                 | 148661        | 147454        | 151939           |
|               |         | Total                         | 18.17                | 286142        | 283818        | 292451           |
|               |         | Sheep                         |                      |               |               |                  |
|               | Male    | Lamb (<1 yr)                  | 0.31                 | 4882          | 4842          | 4990             |
|               |         | Ram (1-2 yrs)                 | 0.24                 | 3780          | 3749          | 3863             |
|               |         | Ram (>2 yrs)                  | 0.2                  | 3150          | 3124          | 3219             |
|               |         | Total                         | 0.75                 | 11811         | 11715         | 12071            |
|               | Female  | Lamb (<1 yr)                  | 0.29                 | 4567          | 4530          | 4668             |
|               |         | Ewe (1-2 yrs)                 | 0.25                 | 3937          | 3905          | 4024             |
|               |         | Ewe (>2 yrs)                  | 0.61                 | 9606          | 9528          | 9818             |
|               |         | Total                         | 1.15                 | 18110         | 17963         | 18510            |
Table 3. Live weight (Kg) of different categories of animals

| Species     | Sex  | Age/Type         | Lwt. (Kg) |
|-------------|------|------------------|-----------|
| Cattle      | Male | Calf (<1.0 yr)   | 70.54     |
| (Crossbred) |      | Bull calves (1-2 yrs) | 151.62 |
|             |      | Breeding bull    | 270.41    |
|             |      | Bullocks         | 273.87    |
|             | Female | Calf (<1.0 yr) | 74.90     |
|             |      | Heifer calves (1-2 yrs) | 162.60 |
|             |      | Milking cows     | 296.70    |
|             |      | Dry cows         | 293.80    |
| Cattle      | Male | Calf (<1.0 yr)   | 61.22     |
| (Indigenous)|      | Bull calves (1-2 yrs) | 132.45 |
|             |      | Breeding bull    | 259.87    |
|             |      | Bullocks         | 261.23    |
|             | Female | Calf (<1.0 yr) | 60.23     |
|             |      | Heifer calves (1-2 yrs) | 131.87 |
|             |      | Milking cows     | 203.45    |
|             |      | Dry cows         | 201.34    |
| Buffalo     | Male | Calf (<1.0 yr)   | 74.89     |
|             |      | Bull calves (1-2 yrs) | 173.45 |
|             |      | Breeding bull    | 476.78    |
|             |      | Bullocks         | 475.67    |
|             | Female | Calf (<1.0 yr) | 79.81     |
|             |      | Heifer calves (1-2 yrs) | 175.34 |
|             |      | Milking cows     | 404.76    |
|             |      | Dry cows         | 398.54    |
| Goat        | Male | Kid (<1 yr)      | 7.87      |
|             |      | Buck (1-2 yrs)   | 12.56     |
|             |      | Buck (>2 yrs)    | 19.24     |
|             | Female | Kid (<1 yr) | 7.69      |
|             |      | Doe (1-2 yrs)    | 13.98     |
|             |      | Doe (>2 yrs)     | 17.45     |
| Sheep       | Male | Lamb (<1 yr)     | 8.27      |
|             |      | Ram (1-2 yrs)    | 14.96     |
|             |      | Ram (>2 yrs)     | 21.59     |
|             | Female | Lamb (<1 yr) | 7.91      |
|             |      | Ewe (1-2 yrs)    | 13.51     |
|             |      | Ewe (>2 yrs)     | 18.93     |
|             | Total                                                                 |

Figure 1. Fresh feed intake by different species of livestock.
Figure 2. Dry matter intake (DMI) by different species of livestock.

Figure 3 and 4. CH₄ emission from male & female Bovine (g/Day).

Figure 5 and 6. CH₄ emission from male & female Bovine (Kg/Year).

Figure 7 and 8. CH₄ emission from goat and Sheep (g/Day) & (Kg/Year).
3.3. Estimation of methane emission

The total methane emission estimated from each category of male and female bovine (Cattle and Buffalo) per day is shown in Figures 3 and 4, and per year in Figure 5 and Figure 6. Estimation of methane from sheep and goat are shown in Figure 7 (daily) and Figure 8 (yearly). The total contribution of methane emission from each species was summarized in Figure 9. Comparison between male and female, it was observed that males of all ruminant species studied here at irrespective of their age produced a higher amount of methane than those of females (Figures 3, 4, 5, 6, 7 and 8). Species wise partition revealed that a buffalo contributed the highest amount (43.33%) followed by a crossbred cattle (31.26%), an indigenous cattle (22.78%), a goat (1.48%) and a sheep (1.16%) (Figure 9). In Bangladesh, only four types of livestock are responsible for the emission of CH$_4$ by the enteric fermentation. In the previous study, Jahan and Azad (2013) stated that the major contribution of the emission occurs from cattle which were about $322.5 \times 10^6$ g in 1983-84 and in 2008-09 was about $344 \times 10^6$ g. It is also mentioned in their study that the contribution of goat to CH$_4$ emission is about $71 \times 10^6$ g in 1983-84, $85.60 \times 10^6$ g in 1996 and $112 \times 10^6$ g in 2008-09. It was measured that the total emission of methane (Kg) per day in Gazipur, Tangail, and Mymensingh districts were 13359.15, 13250.65 and 13653.75, respectively, and (‘000’ Kg) per year were 4876.11, 4836.50 and 4983.62, respectively. In the yearly methane production, the contribution of indigenous cattle is comparatively higher (3,100,000 to 3,350,000 Kg/year), followed by crossbred cattle (1,000,000 to 1,050,000 Kg/year), goat (400,000 to 440,000 Kg/year), buffalo (250,000 to 260,000 Kg/year) and sheep (20,000 to 22,000 Kg/year). Considering the total ruminant population in Bangladesh, it was observed that total methane production in Bangladesh was 848,320 Kg/day and 309,630,000 Kg/year from 56.33 million ruminant livestock. The earlier results of methane emission from enteric fermentation in Bangladesh observed by Jahan and Azad (2013) were 407.15 $\times 10^6$ g in 1983-84, 434.98 $\times 10^6$ g in 1996 and 502.10$\times 10^6$ g in 2008-09. An increasing pattern of methane emission over time was observed in their study. The total emission of our study is somewhat lower than the previous study, which is might be due to improved animal nutrition for animal farming in recent years. The species wise contribution was summarized in Figure 10. Considering the species-wise methane emission it was observed that 64.79% (549,610Kg/day and 200,600,000 Kg/year) of the total emission was contributed by 19.08 million indigenous cattle. The 2nd highest emission (20.82%; 176,640Kg/day and 64,470,000 Kg/year) occurred from 4.19 million crossbreed cattle. Goat population (30.33 million) of Bangladesh emitted 8.79% (74,610Kg/day and 27,230,000 Kg/year) of total
methane production. The contribution of Buffalo (0.83 million) and sheep (1.90 million) were 5.17% (43,840 Kg/day and 16,010,000 Kg/year) and only 0.43% (3,620 Kg/day and 1,320,000 Kg/year), respectively. This study is based on the developed methane conversion factors, but furthermore accurate study, we should validate the study with direct estimation method like SF6 Tracer Technique, Respiratory Chamber Techniques, Invitro Gas Production Technique and so on. However, the emission of methane gas from enteric fermentation in Bangladesh should be paid an attention formitigating. Methane is one of the major components of greenhouse gas like carbon dioxide (CO2). The effect of CH4 is almost 23 times higher than those of the effect of CO2. Therefore, the emission of about 100 kg Methane per year for each cow is equivalent to about 2'300 kg CO2 per year (Ogino et al., 2007). According to FAO (2013), agriculture is responsible for 18% of the total greenhouse gas emission of the world. Livestock is taking a major part of emission from agriculture. Almost 30% of the total land of the world’s land surface is now engaged by livestock for farming, feed production etc. Now a day the human population in the world is increasing, the farming for supplying meat, milk and other animal products is also increasing. Hence the production of methane is increasing day by day. Therefore, we cannot disagree that livestock farming has a major impact on climate change and global warming. We have to find out the proper mitigation policy against the emission of methane from enteric fermentation. However, to validate our present study it is recommended to use some direct measurement techniques for measuring the emission of methane from enteric fermentation of livestock.

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Conflict of interest
None to declare.

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