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Article

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 elementsfor 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 crossbreed cattle (20.82%), Goat (8.79%), Buffalo (5.17%) and sheep (0.43%).

Keywords: ruminant; methane (CH4); livestock; dry matter intake (DMI)

1. Introduction

Livestock is an integral part of agriculture and likely to be one of the most important instrumentsfor 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 1.90million 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 oflivestock 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 thestorehouse of feeds as well asa 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 fromcropland. These low-quality feeds incur low digestibility and significantly contribute to producinghigh 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 athigher 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 (0-3months) 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) = G2×L/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 contributedhighest 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.

Cattle (Crossbred and indigenous)		Buffalo	
Male	**Female**	**Male**	**Female**
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		**Sheep**	
Male	**Female**	**Male**	**Female**
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 (Crossbred)	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 (Crossbred)	Male	Calf (<1.0 yr)	70.54
		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 (Indigenous)	Male	Calf (<1.0 yr)	61.22
		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	

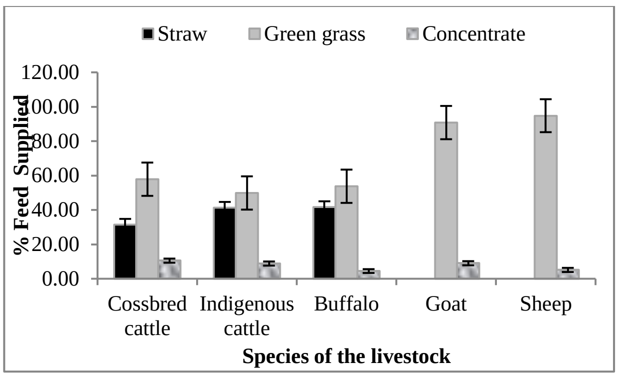


Figure 1. Fresh feed intake by different species of livestock.

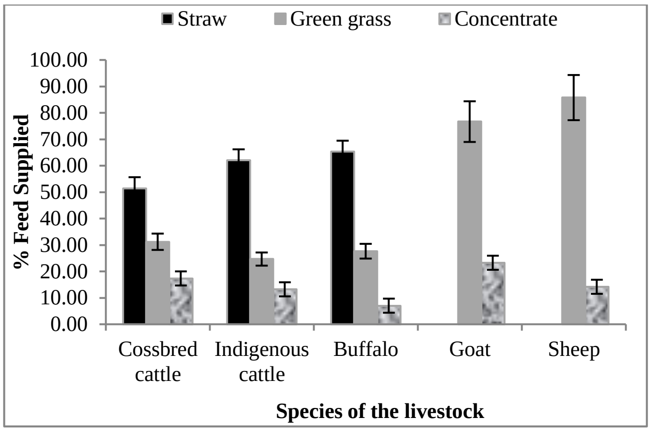
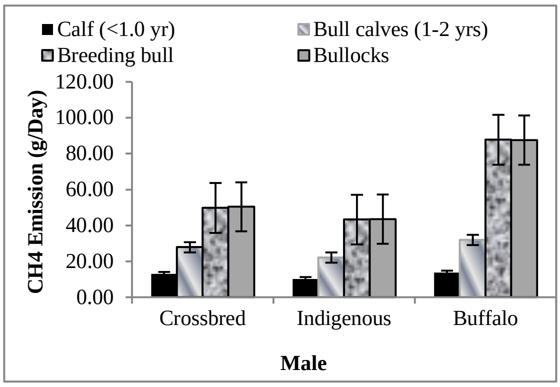


Figure 2. Dry matter intake (DMI) by different species of livestock.



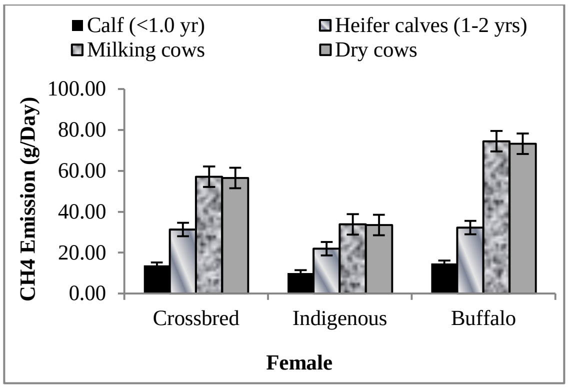
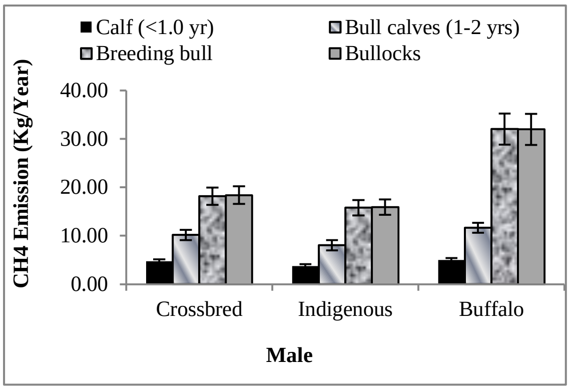


Figure 3 and 4. CH_4 emission from male & female Bovine (g/Day).



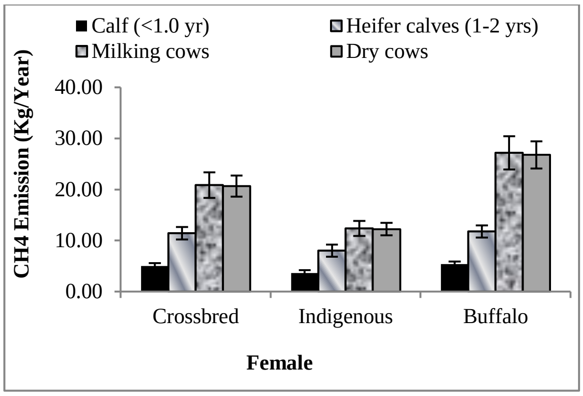
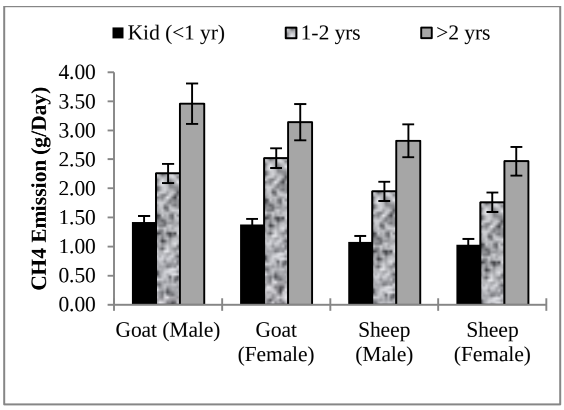


Figure 5 and 6. CH4 emission from male & female Bovine (Kg/Year).



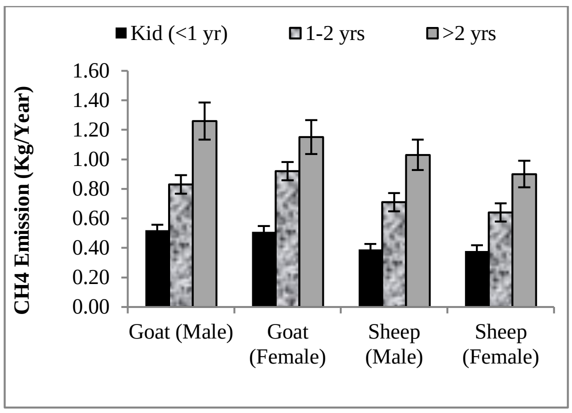


Figure 7 and 8. CH_4 emission from goat and Sheep (g/Day) & (Kg/Year).

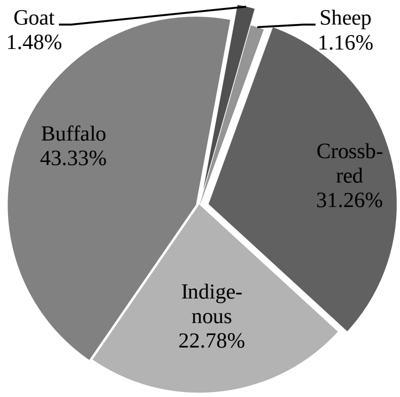


Figure 9. The total individual contribution of CH_4 emission from Different species.

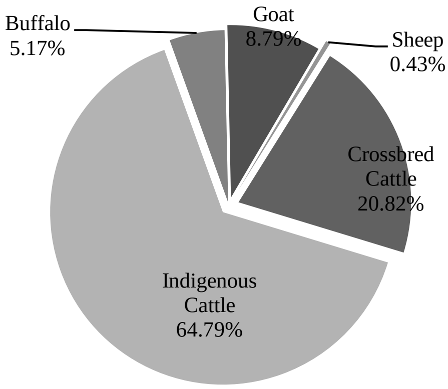


Figure 10. Total contribution of CH_4 emission from Different species in Bangladesh.

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 322.5×10^6 g in 1983-84 and in 2008-09 was about 344×10^6 g. It is also mentioned in their study that the contribution ofagoatto CH_4 emission is about 71×10^6 g in 1983-84, 85.60×10^6 g in 1996 and 112×10^6 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 407.15×10^6 g in 1983-84, 434.98×10^6 g in 1996 and 502.10×10^6 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% (43,840Kg/day and 16,010,000 Kg/year) and only 0.43% (3,620Kg/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 SF_6 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 ofgreenhouse gas like carbon dioxide (CO_2). The effect of CH_4 is almost 23 times higher than those of the effect of CO_2. Therefore, the emission of about 100 kg Methane per year for each cow is equivalent to about 2'300 kg CO_2 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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