A study on estimation of methane gas emission from beef cattle of Bangladesh

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Abstract

Population is increasing day by day in Bangladesh. So people are very much engaged in farming now a days. As farming is increasing, so the effect of greenhouse gas also increasing, which is a great threat to our environment. The agricultural sector emits large quantities of greenhouse gas. Which is responsible for global warming (Jahan and Azad 2013). Some of the major greenhouse gas are methane, carbon dioxide, nitrous oxide etc. In our study, we have discussed about the methane emission from beef cattle in Bangladesh. We followed intergovernmental panel of climate change (IPCC) guideline in our whole study (Das et al., 2020). We used Tier 1 and Tier 2 methods for the calculation of methane emission from beef cattle of Bangladesh. In tier 1 method we calculated the methane emission by using emission factor provided by IPCC 2006 and 2019. According to IPCC 2019, we also calculated the methane emission using tier 2 method which is based on dry matter intake. Finally we have compared our calculated value. After calculation, in 2018, 2019, 2020, 2021 total emission of methane from beef cattle based on Tier-1 (IPCC-2006) is 9990.00Gg, 10777.75Gg, 9996.75Gg and 10111.50Gg respectively. Again based on IPCC-2019 emission of methane is 17020.00Gg, 17169.50Gg, 17031.50Gg and 17227.00Gg respectively. Using Tier 2 method (IPCC-2019) methane emission from beef cattle in 2018, 2019, 2020, 2021 is 16087.60Gg, 16228.91Gg, 16098.47Gg and 16283.26Gg respectively.

Chapter-I

Introduction

The emission of greenhouse gases (GHGs) is a global concern because of their huge climate change impacts. CO_2, CH_4 , N_2O are the major greenhouse gas. Where methane is 20% more potent than CO_2. Global CH_4 emission was about 570 million ton CO_2e, where enteric fermentation of ruminant and their manure management share 31% and 6% respectively. It is important to accurately determine emission from ruminants that meets standardized international guideline for national greenhouse gas inventories (Hoque et al., 2017). Agricultural sector is the major contributor in emission of greenhouse gas. About 39% of total emission comes from the agricultural subsector activity. Among which 31% comes from the enteric fermentation of ruminants. Beef are the herbivores. Methane is produced as a byproduct of enteric fermentation. Total (2-12)% gross energy is lost during the methane production (Das et al., 2020). The number of beef cattle is increasing day by day. In 2016 number of beef cattle is 14.55×10^6 and 2021 number of beef cattle is 14.98×10^6 (Das et al., 2020). So accordingly methane production is also increasing. Landfills, oil, natural gas systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment and certain industrial processes all are the sources of methane emission.

In our study we will show the calculation of total methane emission from beef cattle on Bangladesh perspective.

Objectives:

1. To estimate methane emission from beef cattle of Bangladesh.

2. To compare the CH_4 emission between T1 and T2 model of IPCC 2006 and 2019.

Chapter-II

Review of literature

Intergovernmental panel for climate change has provided three different methods to estimate methane emission from beef cattle by enteric fermentation and manure management. Among them tier 1 methods is most popular. For tier 1 method emission factor for different categories of livestock was provided by IPCC 2006 and 2019. Calculation was very simple to obtain methane emission from different categories and sub-category. Again for tier 2 system, emission factor need to be developed for different livestock category and subcategory. Emission factor development can be done either on dry matter intake and gross energy basic. The final calculation is same as tier 1 method (Eggelosten et al., 2019).

Again the tier 3 system is mainly country-specific system.

According to Das et al. (2020) total methane emission from enteric fermentation of ruminant livestock are estimated. Here, tier-1 and tier-2 method was used. In case of tier 1 we use the data of IPCC and in case of tier-2 emission factor is calculated based on dry matter intake of ruminants (Das et al., 2020). In our report, body weight of different cattle categories are collected from BLRI.

Global livestock sector emission contributes to about 18% of anthropogenic greenhouse gas. According to Das et al. (2020) livestock greenhouse gas emissions in Bangladesh was estimated to 30,124 gigagram (Enteric fermentation) (Das et al., 2020)

Chapter-III

Materials and Methods

Based on IPCC there are three methods to estimate methane emission from beef cattle. These are tier1, tier 2 and tier 3. Here we will describe all the three methods and will show our calculation based on tier 1 and tier 2.

Tier-1 Method:

Most simplified method. Mainly in this report we used the tier 1 method to calculate the methane emission from beef cattle. For each category there is IPCC provided emission factors. Then every category will be multiplied by respective emission factor and 25 and divided by 10^6 (Eggelosten et al., 2006).

Total emission for enteric fermentation = $\sum T\{EF(E,T).N(T)\} \times \frac{25}{10^6}$ Gg/year CO_2e

Total emission for manure management= $\sum T\{EF(M,T).N(T)\} \times \frac{25}{10^6}$ Gg/year CO_2e

Here,

EF=Emission factor

N=Number of cattle

T=Category (beef/Others) (Eggelosten et al., 2006).

For Indian subcontinent, IPCC-2006 and IPCC-2019 provided emission factor for different cattle category.

Table-1: Emission factor provided by IPCC-2006 (Eggelosten et al., 2006).

Category(Beef and Dairy)	Emission factor(kg/cattle/year)
1.Beef cattle	27
2.Dairy cattle	58

Table-2: Emission factor provided by IPCC-2019 (Eggelosten et al., 2019).

Category(Beef and Dairy)	Emission factor(kg/cattle/year)
Beef	46
1.Beef cattle(High productive)	41
2.Beef cattle (Low productive)	47
Dairy	73
3.Dairy cattle(High productive)	70
2.Dairy cattle(Low Productive)	74

Based on IPCC-2019, there is an updated form of tier-1 method which is called as tier-1a methods. In case of T-1a system, beef and other cattle are again subdivided into high and low productivity. IPCC-2019 provided emission factor for each subcategory (Eggelosten et al., 2019).

Tier-2 Method:

Final calculation of tier-2 system is same as tier-1 system. But in case of tier-2 system we need to calculate specific emission factor for each category of cattle while in tier-1 and tier-1a system emission factor is provided by IPCC. There are three steps of tier-2 method (Eggelosten et al., 2019).

Steps 1:

Livestock population (The animal population data and related activity data) should be obtained.

Steps 2:

The emission factors for each category of livestock are estimated based on the gross energy intake and methane conversion factor for the category. The gross energy intake data should be obtained using the following approach. The following sub-steps need to be completed to calculate the emission factor under the tier 2 method (Eggelosten et al., 2006).

Mainly we have performed the calculation of methane emission based on dry matter intake.

So, Emission factor (EF) = DMI× $(\frac{MY}{1000})$.365

Here,

EF = Emission factor, $kgCH_4$ $head^{-1}$ yr^{-1}

DMI = kg DMI per day

MY = Methane yield, $kgCH_4$ $kgDMI^{-1}$

Than,

DMI= $BW^{0.75} \times (0.0582.\mathrm{NE_{mf}} - 0.00266.\mathrm{NE_{mf}}2 - 0.0869/0.239\ .\mathrm{NE_{mf})}$

Here,

DMI= Dry matter intake

NE_{mf}= Estimated dietary net energy concentration of the feed or diet

BW=Body weight.

Table 3: Examples of NE_{mf} content of typical diets fed to cattle for estimation of dry matter intake (Eggelosten et al., 2019).

Diet type	NE_{mf} (MJ (kg dry matter)$^{-1}$)
High grain diet > 90%	7.5 - 8.5
High quality forage (e.g., vegetative legumes and grasses).	6.5 - 7.5
Moderate quality forage (e.g., mid-season legume and grasses).	5.5 - 6.5
Low quality forage (e.g., straws and mature grasses).	3.5 - 5.5

Development of methane yield (MY):

The extent to which feed energy is converted to CH_4 depends on several interacting feed and animal factors and that rate of conversion is embodied in the methane conversion factor (Y_m), defined as the percentage of gross energy intake converted to methane. If we calculate based on ‘dry matter Intake’ another parameter ‘Methane Yield (MY)’ comes. IPCC provided both Y_m and MY for specific cattle category (Eggelosten et al., 2019).

Table 4: (Eggelosten et al., 2019)

Description	Feed quality digestibility (DE %) and neutral detergent fibre (NDF, % DMI).	MY (g CH_4 kgDMI$^{-1)}$	Ym[3]
> 75 % forage	DE ≤ 62	23.3	7
Rations of >75% high quality forage and/or mixed rations, forage of between 15 and 75% the total ration mixed with grain, and/or silage.	DE 62–71	21	6.3
Feedlot (all other grains, 0- 15% forage).	DE ≥ 72	13.6	4
Feedlot (steam-flaked corn, ionophore supplement in 0-10% forage).	DE > 75	10	3

Step-3:

To estimate total emissions, the selected emission factors are multiplied by the associated animal population and summed. As described above under tier-1, the emissions estimates should be reported in gigagrams (Gg) (Eggelosten et al., 2019).

Tier-3 method:

Increased accuracy and identification of causes of variation in emissions are at the heart of inventory purpose. Improvements in country methodology, whether as components of current tier 1 or 2 or if additional refinements are implemented with tier 3, are encouraged.

Japanese T-3 method

$$Y = -17.766 + (42.793 \times DMI) - (0.849 \times DMI)$$

$$MEF = (Y/22.4) \times 0.016 \times 365$$

Here,

Y = Daily enteric methane emission per head of cattle (Gigagram CH_4/year) MEF = Methane emission factor (kg CH_4/head/year) (Eggelosten et al., 2019).

Emission of methane based on tier-1 system:

Three steps for completing our calculation of tier-1 system:

Step-1: Categorization and estimation of cattle population. Categories and their population are shown in Table 5. Here, both data are collected from Das et al. (2020) and we use the AGR (Annual Growth rate) to calculate the population in 2020 and 2021. Here, The AGR is 0.27 for dairy, 0.61 for beef, 0.48 for total (Das et al., 2020).

Table 5: The livestock population of Bangladesh ($\times 10^6$ Heads) (Das et al., 2020) (DLS)

Year	Total cattle	Beef cattle	Dairy cattle
2017	24.10	14.68	9.34
2018	24.16	14.80	9.36
2019	24.31	14.93	9.38
2020	24.21	14.81	9.40
2021	24.40	14.98	9.42

Step-2: Emission factor collection from IPCC guidelines. There is a huge change of emission factor between 2006 and 2019. Here, we will show our calculation by considering both emission factors provided by IPCC in 2006 and 2019. IPCC-2019 provide emission factors for both average categories and subcategories. In our calculation we will calculate by considering the average emission factor. Then we will compare our calculation obtained from considering both emission factors.

Step-3: Estimation of total methane emission by multiplying cattle population with emission factors.

Emission of methane based on tier-2 system (2019)

Step-1 (Methane yield development):

Here methane yield is provided by IPCC-2019 for different cattle categories and subcategories. For our Bangladesh perspective methane yield showed in Table 4.

Step-2 (Emission factor development):

The development of emission factor we need DMI value. Again to estimate DMI value we need the data of body weight followed by estimated dietary net energy concentration of the feed or diet (NE_{mf}). The NE_{mf} value given in table 3.

Now we need the body weight from the BLRI acquaintance-16. We found the cumulative live weight (Kg) of native beef cattle of BCB1 (261.3 Kg) or RCC (195.2 Kg). So we made an average to calculate the DMI value. The average is 228.25kg at 24 month of age (Talukder 2017) (Das et al., 2020)

Step-3 (Total emission calculation):

Total emission will be calculated by multiplying the number of cattle with emission factor.

Chapter–IV

Result

For Tier-1 Method:

Here our calculated values are showing in table form. In table-6 we have shown methane emission in gigagram per year based on emission factor provided by IPCC-2006. In table-7 we have shown methane emission in gigagram per year based on emission factor provided by IPCC-2019. In table-8, there is comparison between emission gigagram per year based on emission factors provided by IPCC at 2006 and 2019.

Table-6: Methane emission (gigagram per year) based on emission factor by IPCC-2006.

Years	Emission from beef cattle
2018	9990.00
2019	10077.75
2020	9996.75
2021	10111.50

Table-7: Methane emission in gigagram per year based on emission factor provided by IPCC-2019.

Years	Emission from beef cattle
2018	17020.00
2019	17169.50
2020	17031.50
2021	17227.00

Table-8: Comparison between emissions (gigagram per Year) based on emission factors provided by IPCC at 2006 and 2019.

years	Emission from beef cattle based on IPCC 2006	Emission from beef cattle based on IPCC 2019
2018	9990.00	17020.00
2019	10077.75	17169.50
2020	9996.75	17031.50
2021	10111.50	17227.00

For tier-2 method:

Our calculation of methane emissions based on tier-2 system are shown in table-9 according to IPCC-2019. In Table-10, there is a comparison between the calculation of methane emission using tier-1 and tier-2 system.

Table 9:

Year	No of beef cattle (Das et al., 2020)	Emission from beef cattle (2019)
2018	14.80	16087.60
2019	14.93	16228.91
2020	14.81	16098.47
2021	14.98	16283.26

Table 10: Comparison of methane emission (Gigagram per year) between tier-1 system based on IPCC-2006 and 2019 and tier-2 system based on IPCC 2019 (Eggelosten et al., 2019).

Years	Emission from beef cattle. Tier-1 system (2006)	Emission from beef cattle. Tier-1 system (2019)	Emission from beef cattle. Tier 2 system (2019)
2018	9990.00	17020.00	16087.60
2019	10077.75	17169.50	16228.91
2020	9996.75	17031.50	16098.47
2021	10111.50	17227.00	16283.26

Chapter-V

Discussions

For-tier-1 method:

Here, based on IPCC-2006 in 2018, 2019, 2020, 2021 total methane emission from beef cattle are 9990.00, 10077.75, 9996.75 and 10111.50 gigagram respectively and based on IPCC-2019 these are 17020.00, 17169.50, 17031.50 and 17227.00 gigagram respectively. So, we are seeing that for the difference of emission factor at IPCC-2006 and IPCC-2019 there are difference of around 7115.50 gigagram emission of methane in every year from beef cattle. Again according to Mahmud and Biswas (2022), The methane emission based on tier 1 method (IPCC 2006) in dairy cattle is 539.58, 541.72 542.88, 544.04 gigagram in 2016, 2017, 2018, 2019 respectively. According to IPCC 2019 the emission is 679.63, 681.82, 683.28, 684.74 gigagram in 2016, 2017, 2018, 2019 respectively (Mahmud and Biswas, 2022).

Tier-2 method:

Here, our calculated emission factor for beef cattle is 43.48 kg/cattle/year respectively which are slightly different from IPCC-2006 provided value. In 2018, 2019, 2020 and 2021 our calculated emissions of methane from beef cattle are 16087.60, 16228.91, 16098.47 and 16283.26 gigagram of methane respectively.

If we see the our calculation of total emissions based on Tier-1 (IPCC-2006) and Tier-2 (DMI basis) in 2018, 2019, 2020 and 2021 total emissions of methane calculated using Tier-1 method are 9990.00, 10077.75, 9996.75 and 10111.50 gigagram of methane respectively and on the basis of Tier-2 method total emissions 16087.60, 16228.91, 16098.47 and 16283.26 gigagram of methane respectively.

We can see a difference of around 6171.76 gigagram of methane emission between the calculation using Tier-1 and Tier-2 method in every year. Again according to Mahmud and Biswas (2022) the methane emission based on tier 2 method (IPCC 2006) in dairy cattle is 544.63, 546.39, 547.56, 548.73 gigagram in 2016, 2017, 2018, 2019 respectively (Mahmud and Biswas, 2022).

In Jahan and Azad (2013) a gradual increase of emission methane from 1983 to 2009 was shown. In our study we can also see the gradual increase in the emission of methane from 2018 to 2021 by using every methods of calculation.

Chapter-VI

Conclusion

As the beef cattle population is increasing day by day in Bangladesh, so methane production is also increasing. Following this, greenhouse effects are uprising. So the result of this situation is increasing global warming, respiratory diseases, air pollution etc. So it is the high time to make change in the world. Collection of the expiratory gases of cattle and processing them into useful things can be solution of this problem.

Chapter-VII

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Biography

I am Aminul Islam an intern student of Faculty of Veterinary Medicine at Chattogram Veterinary and Animal Sciences University from Chittagong (Upazilla: Patiya). I have completed my Secondary School Certificate (SSC) and Higher Secondary Certificate (HSC) in 2014 and 2016 respectively. As a future veterinarian after completing DVM, I would like to be a Veterinary Surgeon.