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Original Research Article

Inventories of Methane Emission for Enteric and Decomposition Gasses from Cattle Manure and Its Mitigation Strategies

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Abstract
Livestock is a significant contributor to global methane (CH4) emissions, accounting for 18% to 51% of total emissions worldwide. The purpose of this study is to estimate the CH4 emissions from livestock in Jambi Province, using the Tier-1 method recommended by the Intergovernmental Panel on Climate Change (IPCC). The results show that CH4 emissions range from 7,464,728 to 7,833,349 tons per year, with feces management contributing 160,261 to 166,667 tons per year, and buffalo enteric emissions contributing 2,511,135 to 2,616,185 tons per year. These findings highlight the significant impact of the livestock sector in Jambi Province on global warming. Moreover, this study presents a brief overview of mitigation strategies that can be implemented to reduce CH4 emissions from the livestock sector.

Keywords: Methane emission; global warming; climate change; dairy cattle emission

1. Introduction

In this era, climate change is an international concentration. All countries were focused on reducing greenhouse gas emissions. The first international conference for combat global warming was conducted in 1979 in Geneva (Yoro and Daramola, 2020). During 1979-2022, an international conference was held on the same issue. Even last year, in 2022 United Nations Climate Change Conference or Conference of the Parties of the UNFCCC (COP 27) was the 27th United Nations Climate Change conference, held from 6 November until 20 November 2022 in Sharm El Sheikh, Egypt. The climate change issue is very important for the sustainability of life on earth.

Several studies reported that the production of greenhouse gasses has been increasing (Lubbers et al., 2013; Olivier and Peters, 2020; Shen et al., 2020; Taher et al., 2023). One of the significant emissions of greenhouse gas is methane (CH4) (Barbera et al., 2018). This gas was reported as a responsible gas that caused climate change. The most sector that produces CH4 gas is the livestock sector. More than 20 billion animals using up to 30% of the terrestrial land area are devoted to producing animal feed (Herrero et al., 2016). This sector is very dynamic. A recent report revealed that the livestock sector produced more than doubled during 1995-2004 (Food and Agriculture Organization of the United Nations, 2009). The increasing human population, urbanization, and other social aspect cause this condition.

Several studies also reported mitigation strategies for reducing CH4 emission (Chagas et al., 2019; Min et al., 2022). The general strategies that using for CH4 emissions are using some additives, improved feed digestibility, manure management, soil carbon sequestration in grasslands (Herrero et al., 2016). The strategy of use of feed additive using several chemical compounds, ionophobic antibiotic, enzymes and probiotic cultures reported have abilities to decrease CH_4 (Herrero et al., 2016). Recent studies also reported that feed management is the one of effective strategies to reduce CH_4. This study conducted on Bali cow in Indonesia that give some different feeds, result of the study showed the combination of feed type, feed composition, and additional feed in the form of fermented tofu dregs (Syarifuddin et al., 2021; Habaora et al., 2020; Tiro et al., 2018).

The most, common, and international standard for measuring CH_4 from cattle is Tier 1 from Panel on Climate Change (IPCC). The Tier 1 method is a simplified approach for estimating CH_4 emissions from livestock, including enteric fermentation and manure management. It involves using default emission factors and activity data to calculate emissions, based on national or regional statistics. For enteric fermentation, the Tier 1 method uses an emission factor of 6.5% of gross energy intake (GEI) for beef and dairy cattle, and 4.0% of GEI for sheep and goats. The GEI values are based on the animal's body weight and the quality of its feed. For manure management, the Tier 1 method uses an emission factor of 25% for liquid manure systems, and 10% for solid manure systems. The emission factors are based on the type of manure storage system and the climate conditions of the region. While the Tier 1 method is simple and easy to use, it may not provide accurate estimates for individual farms or regions. It is often used as a first step to estimate emissions and can be refined with more detailed data and measurements using Tier 2 or Tier 3 methods.

While previous studies have reported on various strategies for mitigating CH_4 emissions from dairy cattle, there is a gap in the literature regarding CH_4 inventories specifically for enteric and fecal decomposition emissions in Jambi Province. This study is important to fill this gap and provide valuable information about the extent of CH_4 emissions in the region and their impact on the environment and climate change. Moreover, this study outlines various mitigation strategies that could be implemented for dairy cattle in Jambi Province. Thus, the publication of this paper would be a significant contribution to the understanding of CH_4 emissions from dairy cattle in the region and their potential mitigation strategies.

2. Material and Method

2.1. Sample Collections

Data was used in the present study on the cattle population during 2019-2021 in eleven districts and cities in Jambi Province, Indonesia. The secondary data information on greenhouse gasses in Jambi Province was obtained from the local government, a range of farm surveys, scientific publications, advice from experts and internal reports. The primary data were collected by measuring the greenhouse gases emission from cattle manure.

Figure 1. Research location
Source: https://peta-hd.com/peta-jambi/

2.2. Inventories Development of Tier 1 CH_4 Emission

Tier 1, chosen as the default CH_4 emission factor for manure management and enteric fermentation were used to develop the inventories of cattle manure (IPCC, 2006). According to IPCC, the default factor for the fermentation of dairy cows is 68 kg/year. All the measurements in this study follow the IPCC for Greenhouse Gas emission standards. The conversion of CH_4 enteric can be calculated by Eq. 1 to 4.

CH_4 emission enteric: **(1)**

$$CH_{-e}\left(\frac{kg}{year}\right) = cattle\ population\ \times\ FF_e\ (\frac{kr}{year})$$

CH_4 emission in feces management **(2)**

$$CH_{-e}\left(\frac{kg}{year}\right) = cattle\ population\ \times\ F_{em}$$

Conversion of CH_4 to CO_2 enteric **(3)**

$$CO_{2-e}\left(\frac{ton}{year}\right) = cattlepopulation\ \times\ F_{em}\left(\frac{kg}{year}\right) \times \frac{21}{1000}$$

The emission factors for enteric CH_4 (FFe) and cattle feces (Fem) were calculated using the Tier 1 method recommended by the Intergovernmental Panel on Climate Change (IPCC). The conversion factor from CH_4 to CO2 is 21/100. The FFe was determined by dividing the population of cows and buffaloes in Jambi Province by the total amount of raw materials processed. The study utilized this method to assess the impact of climate change in the region and provide valuable information for mitigation strategies.

2.3. Impact of CH4 and Mitigation Strategy

This study examines the impact of CH4 and presents mitigation strategies based on recent publications. Google Scholar was used as the search engine to gather information on the impact of CH4 and its mitigation strategies. The keywords used in this study include "CH4 mitigation strategy," "impact of CH4 from dairy cattle," "CH4 impact on climate change," and "strategy for climate change mitigation." The information gathered from these sources provides valuable insights into the impact of CH4 on the environment and identifies effective strategies for reducing its emissions.

3. Result and Discussion

3.1 Cattle Population

The population of castles are one of biggest source of emission factor. The emission factor from CH_4 enteric and feces decomposition can be seen in Table 1. Several studies also reported that cattle impact on climate change. Even in Brazil, a recent study showed that rising cattle significantly impact climate change (Bustamante et al., 2012). Not only in Brazil, but the same condition is also found in China. A study reported greenhouse gas emissions during cattle feedlot manure compost (Bai et al., 2015). In Jambi Province, an increase in cattle was also found. This condition showed the dangerous condition for increasing greenhouse gas. The number of cattle in Jambi Province can be seen in Table 2.

Table 1. The emission factor of CH_4 enteric and decomposition feces.

Type of cattle	Digestive Process (enteric)	Feces decomposition
Beef cattle	47	1
Dairy cow	61	31
Buffalo	55	2
Goat	5	0.22
sheep	1	0.20
pig	18	0.2
horse		0.2
free-range chicken		0.2

Type of cattle	Digestive Process (enteric)	Feces decomposition
laying hens		0.2
broiler		0.2
duck		0.2

Source: (IPCC, 2006)

Table 2. Population of cow and buffalo during 2019-2021 in Jambi Province

Location	Cow			Buffalo		
	2019	**2020**	**2021**	**2019**	**2020**	**2021**
Muaro Jambi	19,415	15,601	13,954	1,121	1,342	1,446
Kota Jambi	1,922	1,526	1,901	96	137	232
Muaro Bungo	39,879	39,558	41,632	5,065	5,373	5,427
Tebo	19,682	20,834	22,338	9,117	9,967	9,992
Tanjung Jabung Timur	21,693	21,204	20,968	84	83	97
Merangin	19,197	17,078	16,489	4,278	4,601	4,613
Batanghari	7,536	9,040	9,838	11,137	10,694	11,913
Sarolangun	9,963	9,758	9,833	8,910	9,016	9,026
Tanjung Jabung Barat	8,984	8,907	9,429	713	731	735
Kerinci	13,736	10,759	8,699	4,935	3,735	3,737
Kota Sungai Penuh	4,660	4,559	5,180	201	355	349
Total	166,667	158,824	160,261	45,657	46,034	47,567

Table 2 informed that the amount of cow and buffalo were increased every year. This condition indicated that Jambi Province has a potential effect on climate change due to the greenhouse gas emission. The highest numbers of cattle in Jambi Province will following by the increasing of milk of yield per cow and buffalo. A recent study showed that this condition will impact on increasing of greenhouse gas. This result informed that GHG emission of cow is 6000-8000 kg/cow/year, whereas further increasing in milk up to 10,000 kg/head/year cow (Zehetmeier et al., 2012).

3.2. Tier 1 Emission Factor

Table 3 Table 3 presents the enteric methane (CH_4) gas produced from cattle rearing activities and the management of feces in Jambi Province for the years 2019, 2020, and 2021. The results show that the enteric CH_4 gas produced from cattle rearing activities in Jambi Province varied over the three-year period, with 7833,349 tonnes/year in 2019, 7,464,728 tonnes/year in 2020, and 7,532,267 tonnes/year in 2021. Similarly, the CH_4 from the management of feces varied over the same period, with 166,667 tons/year in 2019, 158,824 tons/year in 2020, and 160,261 tons/year in 2021.

For buffalo livestock, the enteric CH_4 gas produced over the same period was 2511,135 tonnes/year in 2019, 2531,870 tonnes/year in 2020, and 2616,185 tonnes/year in 2021. Meanwhile, the CH_4 from faecal management for the same period was 91,314 tons/year in 2019, 92,068 tons/year in 2020, and 95,134 tons/year in 2021. The findings of this study provide important information on the CH_4 emissions from livestock rearing activities in Jambi Province and highlight the need for mitigation strategies to reduce emissions.

The comparison of enteric CH_4 and CH_4 gas production from feces management in the 2019-2021 period reveals that cows contribute more CH_4 gas than buffaloes. The relationship between the number of cattle and buffalo populations and the CH_4 gas produced is evident. Globally, enteric CH_4 gas production from ruminants accounts for 17% - 37% of greenhouse gas emissions (Knapp et al., 2014). Jiao et al (2014) reported that enteric CH_4 gas from the livestock sector accounted for 89% of greenhouse gas emissions. Hernández-Zepeda et al. (2017) also reported that enteric CH_4 gas production was the largest contributor to greenhouse gases followed by faecal management. In addition to the livestock population, the activity of decomposition microorganisms also affects CH_4 gas production. CH_4/methane gas is produced from livestock manure as a result of the activity of anaerobic decomposition microorganisms

(Chianese et al., 2010). The amount of CH_4 gas produced is influenced by microorganism activity and optimal temperature (Klevenhusen et al., 2011).

3.3. Provincial Contribution of CH4 Emissions

Table 3 presents the total CH_4 emissions from enteric and manure sources in cow and buffalo populations in Jambi Province. The results indicate that cows contribute more to CH_4 emissions than buffaloes, primarily due to their higher population numbers. This finding is consistent with the IPCC's estimation that cows emit 61 units of enteric CH_4 gas, compared to buffaloes' 65 units. The data also show that despite the number of cattle in Jambi Province being higher than that in Jakarta Province in 2015, CH_4 emissions from cows in Jambi Province are still higher than other cattle in Jakarta Province (Nurhayati and Widiawati, 2017). Given the significant contribution of enteric methane emissions from cattle to greenhouse gas emissions in Jambi Province, it is important to develop and implement effective strategies to mitigate these emissions. One promising approach is through the adoption of nutrition strategies that can help reduce enteric methane emissions from dairy cattle. A recent study published in 2022 has identified several effective nutrition strategies for mitigating enteric methane emissions from dairy cattle, including the use of methane inhibitors, alternative electron sinks, vegetable oils and oilseeds, and tanniferous forages. By implementing such strategies, Jambi Province could significantly reduce the greenhouse gas emissions from its cattle industry, helping to mitigate the negative impacts of climate change (Hristov et al., 2022).

Jambi Province, with a high number of dairy cattle, is also home to vast areas of peat soils, which increases CH_4 emissions in the area. The region's wetlands are even more extensive than those of Japan, exacerbating the situation. This condition, combined with the large number of dairy cattle, poses a significant threat to the global environment. A previous study found that in Muaro Jambi, CH_4 emissions from enteric sources were as high as 1,11274 Gg CH_4/year and 0.0239 Gg $_{CH4}$/year in 2019. Therefore, it is crucial for Jambi Province to develop effective strategies to manage CH_4 emissions, especially from dairy cattle, to mitigate the impact on the environment. Such strategies should aim to reduce the amount of CH_4 produced by dairy cattle while increasing their productivity and overall health (Syarifuddin et al., 2019). This condition will be give negative impact on ozone. The CH_4 emission reported the serious impact in tropospheric ozone response. The simultaneously CH_4 emission for the environment impact on greenhouse warming (Al-Ghussain, 2019). This condition is a dangerous condition as an international focus.

Table 3. Tier 1 inventory of emission in Jambi Province during 2019-2021

Location	CH_4 Enteric from Cow (ton/year)			CH_4 Manure from Cow (ton/year)			CH_4 Enteric from Buffalo (ton/year)			CH_4 Manure from Buffalo (ton/year)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
Muaro Jambi	912,505	733,247	655,838	19,415	15,601	13,954	61,655	73,810	79,530	2,242	2,684	2,892
Kota Jambi	90,334	71,722	89,347	1,922	1,526	1,901	5,280	7,535	12,760	0.192	0.274	0.464
Muaro Bungo	1,874,313	1859, 226	1,956,704	39,879	39,558	41,632	278,575	295,515	298,485	10,130	10,746	10,854
Tebo	925,054	979,198	1,049,886	19,682	20,834	22,338	19,9844	548,185	549,560	18,234	19,934	501,435
Tanjung Jabung Timur	1,019,571	996,588	985,496	21,693	21,204	20,968	4,565	5,335	5,335	0.168	0.166	0.194
Merangin	902,259	802,666	774,983	19,197	17,078	16,449	235,290	253,055	253,715	8,556	9,202	9,226
Batanghari	354,192	424,880	462,386	7,536	9,040	9,838	612,535	588,170	655,215	22,274	21,388	23,826
Sarolangun	468,261	458,626	462,151	9,963	9,758	9,833	490,050	495,880	496,430	17,820	18,032	18,052
Tanjung Jabung Barat	422,248	418,629	443,163	8,984	8,907	9,429	39,215	40,205	40,425	1,426	1,462	1,470
Kerinci	645,592	505,673	408,853	13,736	10,759	8,699	271,425	205,425	205,535	9,870	7,470	7,474
Kota Sungai Penuh	219,020	214,273	243,460	4,660	4,559	5,180	11,055	19,525	19,195	0.402	0.710	0.698
Total	7,833,349	7,464,728	7,532,267	166,667	158,842	160,261	2.511,135	2.531,870	2.616,185	91,314	92,068	95,134

3.4. CH4 Impact on Environmental and Climate Change

CH_4 is one of powerful greenhouse gas that caused by fossil fuel, livestock production, human activities, and dairy cattle utilization. Global change such as environmental degradation and climate change has been reported since 1750's (Reay et al., 2018). According to UNPD report, increasing of CH_4 in atmosphere was increased from 722 ppb to more than 1,800 ppb in 2011 and has been increasing until now. The most of source CH_4 emission from livestock is about dairy cattle. A study informed that ruminant livestock (i.e., cattle, cow, buffalo, goats and sheep) are the cattle that give significant impact on CH_4 emission. CH_4 emission produced under anaerobic condition. The one of factor caused higher emission of CH_4 enteric is eats of cattle.

Not only for cow and buffalo, but a recent study also reported goat is associated with the climate change. This study showed that several factors effected the enteric CH_4 emission from dairy cattle such as weather factor, feed intake, inflow of saliva, dynamic passage of particle, rumen factors, feed factor and rumen microbial factors. The weather factor that associates with CH_4 emission are temperature, relative humidity, solar radiation, wind velocity. The feed factors are type of diet, concentrate, roughage, pasture, frequency of feeding and composition of diet. The rumen associate factors are type and population of rumen microbes, and rumen protozoa concentration (Pragna et al., 2018). Although the previous study showed that goat have lower on enteric CH_4 emission if compared with sheep and other ruminants (Soren et al., 2017).

A study reported that ruminants (i.e., buffalo and cow) are the one of important source of anthropogenic CH_4 emission. The CH_4 emission due to the ruminants called enteric fermentation (Thakuri et al., 2020). The CH_4 emission could impact on climate change that accumulation of this gasses will be generate some negative impact. According to the NASA negative impacts due to climate change are glaciers and ice sheets are shrinking, river and lake ice is breaking up earlier, plant and animal geographic ranges are shifting, and plants and trees are blooming (Figure 1) (National Aeronautics and Space Administration, 2023).

Emission of CH4 reported give an impact on river flood. A recent study informed that a river from China reported exposure the CH_4 into the atmosphere (Tong et al., 2010). CH_4 emission as a one of bigger source caused climate change. CH4 is one air pollutant that abundant in the atmospheric contributing the global warming effect (Liu et al., 2021; Thakuri et al., 2020). CH_4 is second large of anthropogenic contributor for about 150 years (IPCC, 2007). A recent study showed that 60% of CH_4 emission is caused by human activities (Al-Ghussain, 2019). If this emission is not managed well, some consequence such as rising of temperature, impact on oceans and marine life, extreme weather, precipitation and floods (Al-Ghussain, 2019).

3.5. Mitigation Strategy for CH4 from Dairy Cattle

A study informed that several strategies for CH_4 emission from dairy cattle such as improving animal productivity, nutritional and management, and manipulation of rumen fermentation (Maia et al., 2016). The general strategy for CH_4 mitigation from dairy cattle is feces management. The utilization of dairy cattle feces to fertilizer is one of effective plan for reduce CH_4 emission from dairy cattle. The novel strategies for CH_4 mitigation reported in a new study, such as probiotic engineering, bacteriocins, archaeal viruses, immunization, reductive acetogenesis, methane oxidizer, propionate enhancer, essentials oil (Boadi et al., 2004). The summary of CH_4 mitigation strategies for dairy cattle could be seen in Table 4. In addition, Figure 1 also showed the mitigation strategy for CH_4 emission.

Table 4. Summary of CH_4 emission management for dairy cattle

Strategy	Potential Reduction of CH_4	Reference
Immunization	Up to 23%	(Boadi et al., 2004)
Dairy cattle improving productivities	Up to 30%	
forages, grinding/pelleting	Up to 40%	
monensin, lasolocid	Up to 30%	
Probiotic (in vitro)	Up to 50%	
Essential oil	Up to 14%	
CH_4 inhibitors	Up to 71%	
Genetic selection (cross cow)	Up to 11%	(Robertson and Waghorn, 2002)
methanogenesis	Up to 14%	(Broudiscou et al., 2000)
Feed rations	19%	(Wattiaux et al., 2019)
Manure management	24%	

Almost all of countries worldwide focus on CH_4 mitigation due to this negative impact. Start from Kyoto Protocol that showed carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the fluorinated gases such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are need to mitigate. According to the international organization (UNEP) the Greenhouse gas emission that release during 2018 is up to 55.3 $GtCO_2e$. 1.7% of total emission of greenhouse gas is caused by dairy cattle. This condition increases periodically 1.3 over pass decade (Fawzy et al., 2020). Generally, the mitigation strategy for reduce greenhouse gas emission are using the renewable energy, nuclear power, carbon capture, storage and utilization, fuel switch and efficiency gains, bioenergy afforestation and reforestation, biochar, soil carbon sequestration, direct air carbon capture, ocean fertilization (Fawzy et al., 2020). These strategies will help the reducing of greenhouse gas that release from all sources.

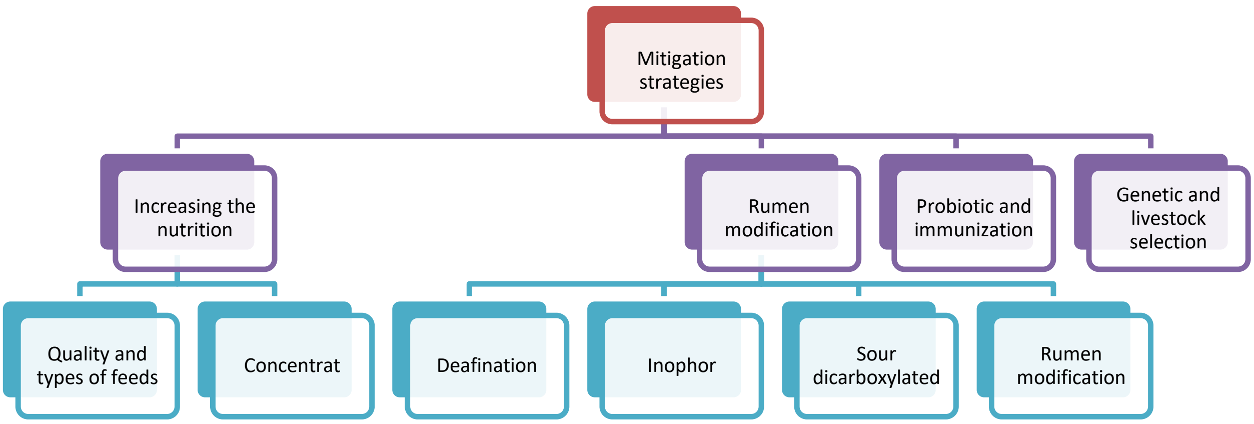

Figure 2. Mitigation of CH_4 for enteric of ruminants

Biochar is a carbonaceous material produced by heating organic matter at high temperatures in the absence of oxygen. The resulting material has a high surface area and porosity (Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023)(Taher et al., 2023), which can be used to improve soil quality and promote carbon (Muhammad et al., 2019). The addition of biochar to dairy cattle feces has the potential to create a novel fertilizer that could improve soil health and reduce CH_4 emissions (Osman et al., 2022). Biochar has been shown to improve nutrient retention and water-holding capacity in soil, which can increase plant growth and crop yields (Allohverdi et al., 2021). Additionally, biochar's porous structure has the ability to adsorb CH_4 emissions from the feces of dairy cattle, mitigating the impact of livestock on greenhouse gas emissions (Maurer et al., 2017; Woolf et al., 2010). While this approach shows promise, further research is needed to evaluate the feasibility and effectiveness of using biochar as a means of managing feces from dairy cattle at a larger scale. Overall, this novel strategy has the potential to provide a sustainable solution for managing livestock waste while also promoting soil health and reducing greenhouse gas emissions. Biochar is carbon base materials that powerful not only for environmental remediation (Wibowo et al., 2022b, 2022a). A recent study also informed that dairy manure could be composting with wood biochar for reducing CH_4 emission (Harrison et al., 2022). This study also discussed about the potential utilization of dairy manure and other organic material for climate change mitigation. Result of this study showed a significant impact on CH_4 reduction after added biochar in dairy manure (Brendan P. Harrison et al., 2022; Nguyen et al., 2020). As s material than created from carbon, biochar is a powerful material for CO2 mitigation. Thus, the utilization of biochar is not only have a positive impact on CH_4 emission mitigation but also for CO2 mitigation (Patel et al., 2021).

The results of the literature review suggest that increasing the nutrition of livestock can be an effective strategy for reducing CH4 emissions (Allohverdi et al., 2021; Benchaar, 2020; C. Valli, 2019; Goopy et al., 2020). The studies indicate that the use of high-quality feed, such as legumes and oilseed meals, can lead to a reduction in CH4 emissions from ruminants (Hristov et al., 2013). Additionally, the use of dietary additives, such as ionophores and nitrates, can also reduce CH4 emissions from livestock. The studies further suggest that the effectiveness of the strategy may depend on the type of livestock and the method used to measure CH4 emissions (Garnsworthy et al., 2019a). rumen modification can be an effective strategy for reducing CH4 emissions from livestock production (Broudiscou et al., 2000; Maia et al., 2016). The studies suggest that the use of dietary additives, such as ionophores, can reduce CH4 emissions by altering the microbial population in the rumen (Garnsworthy et al., 2019b; Tseten et al., 2022). Additionally, the use of plant secondary metabolites, such as tannins, can also reduce CH4 emissions by inhibiting methanogenic bacteria (Bhatta, 2015; Broucek, n.d.). The studies further suggest that the effectiveness of the strategy may depend on the type of livestock and the method used to measure CH4 emissions.

Probiotic and immunization strategies can be effective techniques for reducing CH4 emissions from livestock production (Bhatta, 2015). The studies suggest that the use of probiotics, such as lactic acid bacteria, can reduce CH4 emissions by altering the rumen microbial community (Bhatta, 2015; Króliczewska et al., 2023). Additionally, immunization strategies, such as vaccination against methanogenic bacteria, can also reduce CH4 emissions by decreasing the population of methanogenic bacteria in the rumen (Kumar et al., 2014; Wedlock et al., 2013). Genetic and livestock selection strategies have shown promise in reducing CH4 emissions from livestock production(Knapp et al., 2014; Pickering et al., 2015). Studies have found that animals with low residual feed intake (RFI) tend to have lower CH4 emissions, suggesting that selection for low RFI can be an effective means of reducing CH4 emissions (Alemu et al., 2017; Fitzsimons et al., 2013). This is thought to be due to the fact that animals with low RFI have more efficient digestion, resulting in less methane production. Additionally, selecting for animals with a different rumen microbial population, such as through crossbreeding, can also reduce CH4 emissions. By selecting for animals with a lower number of methanogenic microbes in their rumen, CH4 production can be reduced. However, further research is needed to determine the effectiveness of these selection strategies across different livestock species and production systems.

4. Conclusion

Greenhouse gas emissions, particularly CH_4, have a significant impact on the environment, leading to climate change. The livestock sector is one of the largest contributors to CH_4 emissions worldwide, accounting for up to 51%. In Jambi Province, CH_4 emissions from cattle and buffalo rearing activities ranged from 7464.728 to 7,833,349 tons/year, while emissions from feces management were between 160.261 and 166.667 tons/year. Buffalo enteric CH_4 emissions ranged from 2511.135 to 2,616,185 tons/year, with emissions from feces management ranging from 91,314 to 95,134 tons/year using Tier 1. Effective strategies for mitigating CH_4 emissions from dairy cattle include improving nutrition, modifying rumen microbial populations, and implementing feed engineering. Additionally, adding carbon material such as biochar to manure can also reduce CH_4 emissions from dairy cattle. Given the scale of the problem and the importance of addressing it, it is crucial to implement effective and sustainable strategies for mitigating CH_4 emissions from livestock activities.

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