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MITIGATION PRACTICES FOR GREENHOUSE GAS EMISSIONS IN ANIMAL HUSBANDRY

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ABSTRACT

Animal husbandry significantly contributes to greenhouse gas (GHG) emissions, with livestock accounting for an estimated 7 to 18 percent of global anthropogenic emissions. Mitigation strategies targeting enteric methane (CH4) and management of manure are critical for lowering the environmental effect of animal production. This paper reviews current mitigation practices, including dietary strategies, feed supplements, manure management techniques, and climate-smart livestock management. Emphasizing the complex interactions between these practices, this review highlights the contribution of improving Animal performance and well-being as key strategies for GHG emission reduction. It also explores the capability for synergistic approaches to limit the emissions across multiple components of the animal production system.

Keywords: Enteric methane, Manure management, Mitigation practices, Animal health, Productivity.

INTRODUCTION

Animal production is a significant source of greenhouse gas (GHG) emissions, primarily in the form of methane (CH4) and nitrous oxide (N_2O). The contribution of livestock to global anthropogenic GHG emissions is estimated between 7 to 18 percent, depending on the methodology used by organizations like the IPCC, FAO, and EPA. To mitigate these emissions, it is essential to evaluate and implement effective practices within livestock management. This paper reviews mitigation strategies for reducing enteric CH4 and manure-related GHG emissions, examining the potential of dietary interventions, feed supplements, manure management, and climate-smart livestock practices.Emissions of greenhouse gases (GHGs) from the livestock segment primarily originate from digestive processes in herbivores, known as enteric fermentation, as well as from the storage and treatment of animal waste. Between 2005 and 2018, emissions from this sub-sector increased at a modest compound annual growth rate (CAGR) of approximately 0.01%, whereas a comparatively faster rise of around 0.07% was recorded during 2012–2018. Using the trend observed over 2005–2018, total emissions from livestock are expected to reach about 222.68 million tonnes of CO_2 equivalent by 2030.Dunkley, 2012 studied regarding the carbon footprint of poultry production farms,

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the study focused on assessing greenhouse gas (GHG) emissions-specifically carbon dioxide, methane, and nitrous oxide-under the control of poultry growers. A range of factors-such as the size of livestock populations, animal mass, feeding patterns, waste management systems, and regional terrain-significantly affect emission outcomes. (EPA, 2011) reviews U.S. greenhouse gas emissions from 1990 to 2009, identifying a net increase in total emissions over the two decades, The present analysis reviews historical emission trends, estimates future levels up to 2030, and proposes suitable mitigation strategies to curb emissions from the livestock sector primarily driven by energy-related CO_2

1.Enteric CH4 Mitigation Practices

Forage Quality and Digestibility.

Improving forage quality and digestibility is one of the most effective ways to reduce GHG emissions from ruminants. Increasing the digestibility of forage and enhancing the intake of digestible forages typically leads to a reduction in CH_4 production during rumen fermentation. Replacing grass silage with corn silage or legume silages can also lower CH_4 emissions due to their lower fiber content and the added benefit of reducing the need for synthetic nitrogen fertilizers. Legume integration into grass pastures in warm climates may offer a potential mitigation opportunity, though further research is needed to assess agronomic challenges and the comparative effects on N_2O emissions.

Broderick *et al.* (2002) compared ryegrass silage and alfalfa silage in a total mixed ration for lactating dairy cows. Although both diets had similar nitrogen and NDF levels, the alfalfa silage diet contained higher total and indigestible ADF. Cows fed alfalfa silage consumed about 50% more feed and produced 15% more milk, but feed efficiency was lower compared to the ryegrass silage diet. In contrast, fibre digestibility was about 50% higher with the grass silage diet. These results indicate that forage composition and digestibility influence feed intake, animal productivity, and potentially greenhouse gas emissions.

Feed Supplements

Several feed supplements can reduce enteric CH_4 emissions, including dietary lipids, concentrates, nitrates, ionophores, tannins, and direct-fed microbials. Lipid supplementation is effective, but economic feasibility and potential impacts on feed intake and animal health need to be considered. High-oil by-product feeds such as distiller's grains offer a viable option, though their higher fiber content may counteract the desired CH_4 reduction. The inclusion of concentrate feeds above 40 percent of dry matter intake decreases enteric CH_4 emissions per unit of animal product, depending on feed type and composition. Additionally, nitrates, ionophores, and tannins show moderate potential in mitigating CH_4 emissions, although their practical application is constrained by issues such as toxicity, feed intake reduction, or limited effects on productivity.

The main factor influencing emissions in the case of enteric fermentation is the quantity of animals; the larger the flock, the higher the emissions. Other factors that affect methane emissions include diet-related factors like the animals' average body weight, gross energy intake, and topographical variations (Department of Animal Husbandry & Dairying, 2018). It should be mentioned that bovines accounted for about 88% of the livestock subsector's emissions in 2018. Average bovine emissions accounted for 88% of these

Table1.Year wise data of Total Population of Indigenous cattle,CB cattle and Buffaloes

Cattle census (Yr) (Dept. of Animal Husbandry & Dairying, 2018)	Total Population of Indigenous cattle (in thousands)	Total Population of Cross-bred cattle (in thousands)	Total Population Buffalo of (in thousands)
1992	189,369	15,215	84,206
1997	178,782	20,099	89,918
2003	160,495	24,686	97,922
2007	166,014	33,086	105,342
2012	151,170	39,732	108,702
2019	141,763	51,410	109,852

emissions, emissions due to indigenous cattle (~41 %), buffaloes (42%) and the remaining crossbred cattle contributes 17%.

As indicated in Table 1, the population of indigenous cattle has shown a steady decline, falling from 189,369 thousand heads in 1992 to 141,763 thousand heads in 2019 (Department of Animal Husbandry & Dairying, 2019). This reduction contributed to an estimated mitigation of about 42.5 million tonnes of CO, equivalent emissions in 2018 when compared to 1992 levels. In this context, improving cattle productivity while reducing emission intensity and regulating the population of low-yielding breeds can serve as an effective mitigation approach, offering both environmental and socio-economic benefits. However, the natural decline in indigenous cattle numbers may reach a threshold beyond which further reduction is unlikely. Therefore, proactive policy measures and targeted interventions may be required to manage indigenous cattle populations within the broader rural economic framework.

2.Manure Management Mitigation Practices

Compared to enteric fermentation, methane emissions from manure management are often lower. Furthermore, the types of management systems that are employed have a substantial impact on the emissions of nitrous oxide from manure management. FAO (2010) shows that Emissions from manure management increased from 20.69 million tonnes CO_2e in 2012 to 20.90 million tonnes CO_2e in 2018, with a compound annual growth rate (CAGR) of 0.16 percent.

Diet and Manure Chemistry

Dietary adjustments significantly influence manure composition and GHG emissions. Decreasing protein levels in ruminant diets and balancing protein with rumen-degradable sources can reduce ammonia and N_2O emissions from manure. Low-protein diets for non-ruminants, supplemented with synthetic amino acids, also help mitigate N_2O and ammonia emissions. Grazing restrictions and optimizing fertilizer application on pasture can further reduce N_2O emissions, while improving manure storage systems, such as anaerobic digestion and composting, can reduce methane emissions.

Soil Fertility and Fertilizer Management

Optimizing manure application and improving soil management practices can reduce emissions from land-applied manure.

Forages with higher sugar content may reduce urinary nitrogen excretion, ammonia volatilization, and N_2O emissions. Additionally, cover cropping and urease inhibitors can help reduce N_2O emissions, although results are mixed and further research is required. Nitrification inhibitors show promise but can be expensive, limiting their adoption.

Effect on milk production

Scientific estimates suggest that nearly 20–30% of the plant and animal species evaluated to date could face a heightened risk of extinction if the global average temperature rises beyond the range of 1.5°C to 2.5°C. In the Indian context, climate change is expected to adversely affect dairy output, with projected reductions of about 1.6 million tonnes by 2020 and up to 15 million tonnes by 2050. More broadly, developing nations are likely to experience significant losses in livestock productivity, potentially declining by nearly one-fourth due to changing climatic conditions.In India, climate change is believed to reduce milk production by 1.6 MT&15 MT in 2020 & 2050 respectively (Upadhyay *et al*., 2008). Duetoclimate change, developing countries may lose 25 per cent of animal production (Thornton, 2010). Based on Garg *et al.* (2012), feeding balanced rations to lactating animals (cows/buffaloes) under field conditions increases milk yield by 4.5–6.2% and fat by 0.9–1.8 g/kg per animal.

3. Climate-Smart Livestock Management for Sustainable Farming

Enhancing Animal Productivity

Enhancing animal productivity is a highly effective strategy for reducing GHG emissions per unit of livestock product. Genetic improvements, balanced diets, and increased reproductive efficiency can significantly reduce emissions by increasing the output of individual animals while maintaining or reducing herd size. For instance, reducing the age at slaughter for beef cattle and optimizing nutrition can lower emissions intensity. Additionally, selecting animals with lower feed conversion ratios can help reduce the environmental footprint of livestock production.

Animal Health and Reproductive Management

Improved animal health, reduced morbidity, and increased productivity contribute to lower GHG emissions per unit of production. Reproductive management practices that improve conception rates, fecundity, and reduce embryo wastage can further enhance productivity while lowering emissions. A focus on increasing the productive lifespan of animals and reducing replacement rates is beneficial for reducing the total emissions from the livestock sector.

Interactions Among Mitigation Practices

The interactions among individual components of livestock production systems-such as feed, manure management, and animal health-are highly complex. For example, practices that mitigate enteric CH_4 emissions, such as dietary interventions, may inadvertently increase the fermentable substrates available for methane production during manure storage. Therefore, it is essential to consider the holistic impact of mitigation practices to avoid unintended consequences. Some practices, like improving animal health and productivity, offer synergistic benefits by reducing both enteric CH_4 and manure-related GHG emissions.

CONCLUSION

Improving the quality of forage and the efficiency of nutrient use remains one of the most effective methods for reducing GHG emissions per unit of animal product. Feed supplements, such as lipids, concentrates, and nitrates, show promise in reducing enteric CH_4 emissions, but their long-term effects and economic feasibility remain uncertain. Manure management practices also offer significant potential for reducing GHG emissions, but these must be carefully tailored to the specific context. Optimizing animal productivity, improving reproductive efficiency, and enhancing animal health are key strategies for mitigating GHG emissions. A systems-based approach that considers the complex interactions within livestock production systems is essential for effective and sustainable GHG mitigation.

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