



A Green Misconception: The Real Impact and Role of Ruminants on Greenhouse Gases



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Abstract

Carbon emissions, primarily from burning fossil fuels, deforestation, industrial processes, agriculture, and waste management, are the main drivers of climate change, air pollution, and ecosystem disruption. Energy production is the largest contributor, followed by agriculture, forestry, and land use changes. Ruminants significantly contribute to methane emissions. However, the contribution of methane emissions to global greenhouse gases is relatively low, and the share of ruminants within this is also minimal. Methane has a much shorter atmospheric lifetime than carbon dioxide. Certainly, research on the effective and continuous reduction of methane production in ruminants must persist. Achieving this goal will enhance livestock productivity and mitigate the environmental impact of methane emissions from ruminants.

Keywords: Global warming; Greenhouse gases; Methane Emission; Ruminant

Abbreviations: EPA: Environmental Protection Agency; IPCC: Intergovernmental Panel on Climate Change; FAO: Food and Agriculture Organization; GHG: Greenhouse Gas

Introduction

Global warming, one of the most critical and concerning repercussions of climate change worldwide, is presently on the agenda as a natural calamity. Global warming refers to the increase in temperature on Earth's surface induced by the greenhouse effect caused by gases emitted into the atmosphere due to numerous activities. The greenhouse gas (GHG) effect is a natural phenomenon that maintains the planet's temperature. As the amount of greenhouse gases in the atmosphere increases, they reach levels higher than natural processes can handle and trap more heat than safe levels, causing climate change [1,2]. These gases, known as greenhouse gases, include carbon dioxide (CO₂), methane (CH₄), ozone (O₃), carbon monoxide (CO), nitrous oxide (N₂O), water vapor (H₂O), and halocarbons (such as chlorofluorocarbons-CFCs) [3]. These gases' contribution to global warming varies according to their atmospheric concentration and ability to absorb infrared light [4]. The climate impacts of products/services are generally expressed as CO₂-equivalents using 100-year global warming potentials [5]. According to the breakdown of global emissions, measured based on carbon dioxide-equivalents (CO₂e) in 2022, CO₂ accounts for 75.01% of greenhouse gas emissions, followed by CH₄ (19.47%) and N₂O (5.51%) [4,6].

However, methane is a significantly more potent greenhouse gas than carbon dioxide in terms of its warming potential. Over a 100-year timescale, one ton of methane causes 28 times more warming than one ton of CO₂. Also, N₂O causes 273 times more warming. With this, methane is a short-lived greenhouse gas, with an average atmospheric lifetime of around 12 years, in contrast to CO₂, which can persist for centuries or even millennia. [4] Carbon dioxide emissions have increased substantially during the last 70 years. According to reports, fossil CO₂ emissions in 2021 are 5.1% higher than in 2020. However, they are expected to stay stable, albeit at a relatively high level, during the following decades [7,8]. Carbon emissions refer to releasing carbon, especially CO₂, into the atmosphere. This process primarily occurs due to the burning of fossil fuels, deforestation, industrial processes, agriculture, and waste management [5,6]. Carbon emissions led to significant environmental and health issues, including climate change with severe weather events, melting polar ice, and rising sea levels; air pollution causing respiratory and cardiovascular diseases; ocean acidification harming marine life; and ecosystem disruptions affecting biodiversity, agriculture, and food security [9,10,11]. Methane emissions primarily originate from agriculture, fossil

fuel production, and waste management. Ruminant livestock, such as cattle, goats, and sheep, produce methane through enteric fermentation. Rice cultivation contributes to methane emissions through methanogenesis in waterlogged paddy fields. Biomass burning, including the incomplete combustion of woodlands, savannas, and agricultural waste, also produces methane. Additionally, methane is released from the decomposition of organic waste in landfills and during oil and gas extraction, often termed 'fugitive emissions' [12,13]. Ruminant animals contribute about 16% of the world's total methane emissions. Beef cattle are responsible for 35% of the total methane emissions from livestock, while dairy cattle account for 30% [14].

Global GHG emissions originate from a wide range of sectors, with energy production leading the way. Energy production accounts for 73.2% of greenhouse gas emissions, with industry at 24.2%, transportation at 16.2%, buildings at 17.5%, other fuel combustion at 7.8%, fugitive emissions from energy production at 5.8%, and agriculture and fishing at 1.7%. The share of industry in greenhouse gases is 5.2% (chemicals 2.2% and cement 3%), the share of waste is 3.2%, and the share of agriculture, forestry, and land use is 18.4%. The share of livestock and manure is only 5.8% worldwide [15].

Methane emissions from ruminants

Ruminant animals, including cattle, sheep, and goats, contribute significantly to greenhouse gas emissions with CH₄ and CO₂ [5]. Ruminants produce methane during their digestive process through fermentation, which is primarily expelling via eructation (belching). Additionally, the decomposition of ruminant manure further contributes to greenhouse gas emissions by producing CH₄ and N₂O. Emissions intensities are defined as the GHG emissions per unit weight of product (kg CO₂eq/kg product). Monogastric animals have far lower emissions than ruminants. For example, for pork, it is around 2 kg CO₂eq/kg, and for chicken, it is less than 1 kg CO₂eq/kg, while for beef, it is 32 kg CO₂eq/kg. This high value is due to methane production through ruminant fermentation [16]. It is reported that ruminant animals are responsible for three-quarters of the total CO₂ equivalent (CO₂-eq) emissions from the livestock sector [17]. It is estimated that cattle farming accounts for approximately 4% of global greenhouse gas emissions through methane production [18].

Numerous factors influence greenhouse gas emissions from cattle farming. The most critical elements in this regard are dietary content, feeding procedures, animal genetics, and management strategies. Enteric methane (CH₄) emissions from cattle vary based on factors such as region, age, breed, and productivity. For dairy cattle, key determinants of emissions include animal size and milk production, whereas for other cattle, factors such as animal size, population structure, and production systems are crucial. For instance, the lowest emission values are observed in the smallest cattle, while the highest values are found in highly productive, commercialized dairy systems [19,20]. The type and

nutritional value of the forage or feed consumed by ruminants significantly impacts the methane (CH₄) they release. Methane production in ruminants is a significant concern not only due to its environmental impact but also because it leads to energy loss. The production of methane in ruminants results in the loss of 2-12% of the gross energy contained in feed [14].

For these reasons, research aimed at reducing methane production has been conducted for decades [21-23]. Implementing livestock management methods, incorporating feed additives, and making dietary adjustments can effectively reduce methane emissions produced by ruminant animals [24,25,18].

A meta-analysis indicated that methane emissions from beef and dairy cattle could be mitigated through dietary (such as fat supplementation, higher starch diets, exogenous enzymes, and the use of direct fed microbials) and farm management modifications without adversely affecting production levels [26]. It is reported that total greenhouse gas (GHG) emissions directly associated with livestock production in South Africa remained constant over 20 years, with the intensity of these emissions (per kilogram of animal product) decreasing by 40%, likely due to increased livestock productivity and selective breeding [18].

The contribution of ruminants to methane emissions is indisputable. However, could the role of livestock farming in greenhouse gas emissions, and hence its impact on climate change, be exaggerated? According to FAO data for 2020, due to much faster growth in other emissions, the share of agrifood system emissions in all sectors decreased from 38 to 31 percent in 2020. According to data from the Food and Agriculture Organization (FAO), farm-gate emission intensities have exhibited a significant long-term declining trend across all commodities since 2000, with the most substantial reduction observed in cow milk, which decreased by 24 percent (1 kg CO₂eq/kg) [16]. According to the data from the Intergovernmental Panel on Climate Change (IPCC), the annual CH₄ emission per dairy cow ranges from 58 to 128 kg. The CO₂ equivalent of this amount is 1450-3200 kg annually. For other cattle, the CH₄ emission level is 27-60 kg/year, with a CO₂ equivalent of 675-1500 kg/year [27]. According to Environmental Protection Agency (EPA) data, the CO₂ emission of a typical passenger vehicle is 4600 kg/year [28]. Additionally, the contribution of the internet and technology sectors to greenhouse gas emissions is not negligible. It is believed that artificial intelligence technology, which has developed rapidly in recent years, can be utilized in efforts to mitigate global warming. Reports indicate that artificial intelligence has lower carbon emissions compared to humans in certain areas [29]. Nevertheless, Google reported in its 2023 sustainability report that its total greenhouse gas emissions amounted to 14.3 million metric tons of CO₂ equivalent (tCO₂e), representing a 13% increase compared to the previous year and a 48% increase relative to the baseline year of 2019[30]. Ironically, this increase is attributed to the rising energy demand driven by artificial intelligence.

Conclusion

The contribution of methane emissions to global greenhouse gases is relatively low, and the share of ruminants within this is also minimal. Although methane has a higher global warming potential compared to CO₂, it is removed from the atmosphere much more quickly. Effective strategies exist to reduce methane production in ruminants, aiming to decrease energy waste and increase productivity. Considering all this, methane emissions from livestock should be viewed as the trade-off for efficiently converting high-fiber diets, unsuitable for direct human consumption, into valuable human food sources such as meat and dairy products.

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