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Enteric methane emission from Indian livestock: Status and Mitigation

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Abstract

Methane is the second most potent greenhouse gas contributing 16% of all GHGs. Global Warming Potential of methane is 28 times higher than that of carbon dioxide, however the half-life is only 12 years. Past three decades have seen 2.5-fold rise in the methene concentration due to anthropogenic activities including agriculture and notably by the ruminants. Globally, Brazil and India are the major contributors of livestock generated methane. In ruminants, enteric methane emissions accounts for 5-10% of GE. Indian ruminants emit nearly 9.253 Tg of methane every year with the Uttar, Rajasthan, Maharashtra and Gujarat are the top contributing states (Bhatta *et al.*, 2017). Rumen methanogenesis is an essential inefficiency as it removes excess hydrogen from rumen but at the cost of feed energy. Therefore, enteric methane emissions mitigation would help in reducing the environmental impact as well as improve productivity by conserving the feed energy.

Several approaches have been used to control the enteric methane production in ruminants. The easier and cheaper approach is rationing balancing, that helps in reducing the enteric methane emissions by 8-10%. Plant secondary metabolites like tannins, saponins, essential oils are also useful in controlling the enteric methane production. Various tree leaves have been evaluated for their effect on rumen methanogenesis which can reduce the enteric methane emission by ~10%. Oil and lipids are also effective in suppressing the rumen methanogenesis, mostly by defaunation. Among the different oils, silkworm pupae oil was reported to be most potent at lowest dose level and has long term effectivity (thirumalaisamy *et al.*, 2022). Tanniferous agricultural by-products have been successfully used at NIANP to develop anti-methanogenic feed supplement Harit Dhara (Malik *et al.*, 2022). Recently, seaweeds (red and brown) are also being used for reducing the enteric methane emissions and bromoform from the red seaweed has been established as most potent inhibitor of the enteric methanogenesis (Mohapatra *et al.*, 2024). Novel approaches like anti-methanogenic vaccines, archaeal phages, and breeding for low methane producing animals is also being explored.

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In conclusion, we still need to generate our country specific data on the other livestock related GHGs like nitrous oxide and methane from the excreta. Cheaper and sustainable alternatives as anti-methanogenic supplements that should be available in different regions of the country round the year. Further, the anti-methanogenic supplements should be economic, with long term effect and should also favour correction of the energy inefficiency in the ruminants.

Key words- Bioresource use; feed; oat brewery waste; methane; microbiota

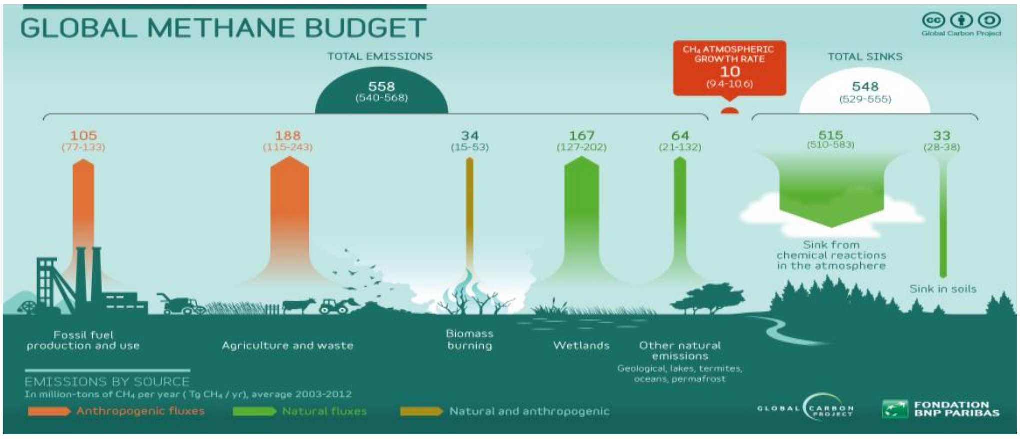
Introduction

India possesses the largest livestock population in the world, majorly reared by small and marginal farmers who either have no land or extremely small holdings (<2 hectares) or cultivate the fodder for their livestock. The country is facing an acute shortage of concentrate, dry, and green fodder, which is further aggravated by the food-feed competition. Indian livestock primarily thrives on crop residue-based diets, which are not only deficient in critical nutrients but also produce very high emissions of enteric CH_4.

With an average concentration of 1.89 ppm, CH_4 is the second most prevalent greenhouse gas in the atmosphere. The atmospheric concentration of CH_4 is steadily rising at a rate of 10–13 ppb per year. However, during 2020, an increase of more than 15 ppb was recorded. Livestock contributes to approximately one-third of the CH_4 emissions due to human activities. In agriculture, enteric fermentation with an average emission of ~90 Tg, remains the single largest source of CH_4 emissions. Each liter of CH_4 production takes 55 megajoules of energy away from the host animal (Malik *et al., 2022*).

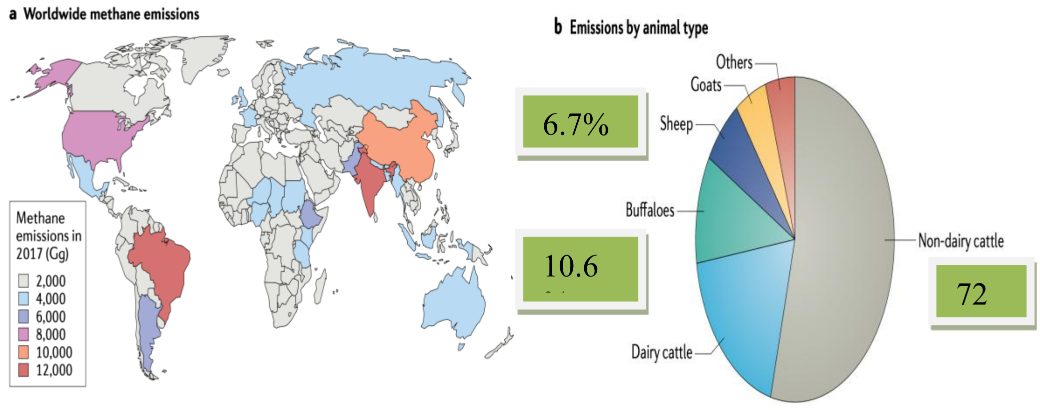
Global methane budget:

Every year 558 tg of methane is being produced from natural aswell as anthropogenic sources. Out of 558 tg only 548 tg is removed from the atmosphere and 10 tg of methane accumulates every year.



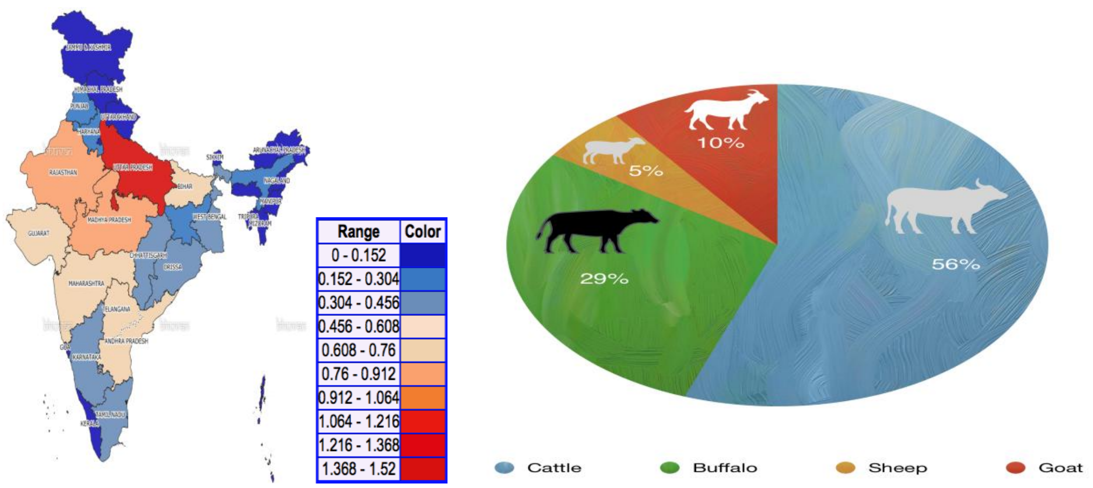
http://www.globalcarbonatlas.o

Worldwide enteric methane emission scenario :



[Mirzahi *et al.,* 2021]

Indian livestock scenario:



[Bhatta et al.,2017]

Introduction of Methanogens:

Earlier methanogens were considered under bacterial domain (prokaryotes), but recent classification by Woese et al., 1990) placed them in a distinct domain, which is remarkably different from bacteria. Methanogens archaea are primarily hydrogenotrophic microbes, which utilize H2 as the main substrate for methanogenesis. Though, they can Use other substrates also for methanogenesis, but H2 remains a central metabolite and its partial pressure determines the degree of methanogenesis. Due to its main role in maintaining the redox-potential (reducing environment) of rumen, H2 is referred as *currency of fermentation*.

Rumen methanogenesis occurs because of the biochemistry of feed fermentation in the rumen, an anaerobic environment in the gut of ruminants Most of the methanogenic archaea in the rumen use H_2 to reduce CO_2 to produce methane (CH_4). This process keeps the partial pressure of H_2 low.

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- There are three main pathways for methanogenesis: hydrogenotrophic, acetoclastic, and methylotrophic.
- There is also another hydrogen sink pathway present in rumen.

Enteric methane amelioration: challenges and opportunities

- **Feeding of quality fodders and concentrate:** Feed interventions are the best option for methane amelioration.
- **Reducing the non-producing livestock**: Due to high number of low producing or non-producing ruminants' methane emission per kg of livestock product is high
- **Ionophore**: Selective inhibition of microbes and failure to achieve the reduction in long term are big issues.
- **Ration balancing:** Ration balancing with feed resources available at farmer's doorstep will improve the productivity.
- **Defaunation**: Removal of ciliate protozoa from the rumen results in lower methane production.
- **Reductive acetogenesis**: Thermodynamics favour methanogenesis in the rumen. The affinity of acetogens for H_2 substrate is considerably lower than methanogens
- **Plant secondary metabolite (tannin and saponin)**: Inclusion at a safe level without affecting the feed fermentability may be a viable option for enteric methane amelioration.
- **Use of nitrate/sulphate**: These reductive processes are thermodynamically more favourable than methanogenesis. The end product from this productive process will not have any energetic gain for the animal.
- **Active immunization**: This approach holds the potential for substantial methane reduction provided methanogen archaea of rumen is explored to a maximum extent for identifying the target candidate for the inclusion in vaccine.
- **Biohydrogenation**: Restricting the H_2 supply to methanogens through alternate use in bio-hydrogenation, decrease enteric methane amelioration.

Conclusions and Future Directions

- GHG emissions from the livestock represents both the energetic and nitrogen production inefficiencies
- Methane is a potent GHG, and livestock annually contribute about 9.25 Tg to the pool
- There is a need to generate primary data on methane and nitrous oxide emissions from the excreta

- For the mitigation, farmers' friendly low input demanding technologies is to be developed, validated and popularized for correcting the production inefficiencies
- Mitigation strategies should be region and seasons specific for the economic viability

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