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Amelioration of methane production from livestock production systems through effective management strategies

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Abstract
Globally livestock has been recognized as one of the major contributors of methane emissions. Enteric fermentation by ruminant livestock *viz*., cattle, buffalo, sheep and goats has been the major source of methane emission. Although livestock sector is envisaged to grow further to meet increasing demand of food from animal produce, necessity of methane mitigation strategies through different management measures are also emphasised in order to reduce the climate change impacts. In the present paper possible methane mitigation measures from livestock production systems through different management strategies *viz*., dietary manipulation, proper selection of animal breeds, manure management and other advanced technologies have been discussed.

Keywords: Methane emission, livestock, management strategies, methane amelioration

1. Introduction

Atmospheric methane (CH_4) is the second most important greenhouse gas (GHG) after carbon dioxide, which has been contributing significantly to the global warming and climate change. Last few decades have witnessed 1-2% increase in methane emission per year [17, 40]. It has been estimated that the anthropogenic activities *viz*., fossil fuel production and its burning, livestock farming, agriculture, landfills etc. contribute 60-70% of global methane production [28]. Further, assessment of GHG emissions showed that livestock contributes about 18% to the global GHG emissions [42]. The animal production systems, mainly ruminant livestock such as cattle, buffalo, sheep and goats, have been known to be major source of methane emission [42, 37, 8]. It has been estimated that globally the beef and cattle milk production sub-sectors account for bulk of the methane emissions, contributing 41% and 20% respectively to the emissions of the sector [9], which envisioned to have higher emission shares with further growth of the sector. The methane production from the livestock production systems occurs mainly from the enteric fermentation and manure management [38, 36]. Methane emissions from livestock are a function of their population density- mainly of ruminants, their production levels and the systems followed during handling of the manure [22].

India possesses world’s largest livestock population sharing nearly 17% of the global livestock population [12]. Among all, the cattle and buffaloes with total population of over 300 million aggregately discharges about 90% of the total enteric methane in the country [25]. The enteric methane emission from the livestock in India is about half (49.1%) of total enteric methane, followed by buffalo (42.8%), goat (5.38%) and sheep (2.59%) and other (0.73%) [34]. In order to meet the increasing demand of food supply from livestock sector for the ever-growing human population, it is necessary that the growth of the animal produce is assured. At the same time due emphasis is also required to be given to limit the environmental burden of increased methane emission through strategic action plan on varied mitigation strategies. Through the present paper an effort has been made to discuss effective methane mitigation strategies in livestock production systems through effective management measures.

2. Mitigation Strategies

Bearing in mind the fact that livestock has been considered as one of the major anthropogenic sources of methane production, action on reduction in enteric methane gas production in ruminants through microbial and dietary manipulation, and manure management are considered to be of high relevance today.

By limiting the production of this greenhouse gas, livestock sector itself can play a significant role in amelioration of methane and thereby mitigating the impact of climate change.
The methane producing bacteria (methanogens) reside in the reticulo-rumen and large intestine of ruminants. These bacteria use a wide range of substrates which are produced during the primary stage of fermentation and produce methane gas. The unique environment in the rumen also helps to assemble a community of distinct archaea - mostly the methanogens, which produce methane by scavenging hydrogen and carbon dioxide produced by other fermentative ruminal microbiomes [35]. It may be possible to reduce the methanogenesis through microbial interventions in the rumen, which however, need to be seen that during such course the microbial processes in the bioconversion of lignocellulosic feeds to the nutrients is not adversely affected. Certain microbial species, *viz*., rumen protozoa have coevolved with ruminants, which do not exist in any other environment [22]. The microbial interventions generally include suppression of methanogenic archaea, protozoa inhibition, reducing hydrogen generation and enhancing reductive acetogenesis.

2.1 Feed and Feeding Management

Reduction of enteric methane emissions from ruminants has been a global objective, which can possibly be achieved mainly through diet manipulation, efficient feed conversion and use of appropriate feed additives [26, 9]. Dietary manipulation not only ensures better animal productivity but is also considered to be the simplest and rational approach for methane mitigation [15]. Certain feeds can enhance propionate or lower acetate production thereby decreasing H_2 that would be converted to CH_4 [22]. The diet composition being an important factor which affects rumen fermentation and methane production process, provision of improved feed quality can also be an important intervention course for inhibition of methanogenesis. The enteric methane emission rate in livestock varies with feed intake and digestibility [14]. The type of feed concentrates also found to have influence on methane production potential [3]. Decreased methane emission was observed with supplementation concentrate at 80 and 90%, whereas at 35 and 60% no effect was found [23]. Although the effectiveness of the feed management strategies on absolute emissions is normally estimated to be low to medium, these options hitherto would be able to substantially lower emission intensity substantially [9].
The animals grazing on lower quality of fodder found to produce higher amount of methane. The ruminants fed on lignocellulose feeds, subjected to different treatments with improved digestibility, found to produce lower methane [2]. The treatment of paddy straw with urea found to result in significant improvement in digestibility of nutrients [41] and also reduction in methane generation [45]. The feeding of high grain in the ration can be an important strategy to reduce methanogenesis, which however, need to have cost consideration in mind. Better feeding management by nourishing nutritious feeds can increase animal productivity and feed proficiency, which can improve propionate or reduce acetate production, causing reduction in hydrogen molecule which later on converts to methane.
Addition of oils, tannins and saponin in the diet has shown to inhibit the methanogens and thereby reduce methane production in ruminants [19, 10, 4, 27, 24]. Further, the medium-chain fatty acids (C_8:C_{14}) from coconut or palm oil has been found to be most effective in mitigating methane [15]. It has been observed that feeding of lipids can reduce methane emissions by 4-5% for every 1% change in the lipid content in feed [26, 13]. Recently, both *in vitro* and *in vivo* studies have also been made on the anti-methanogenic activity of tannins, showing their positive impacts in methane amelioration [11]. Study has shown that by adding the ethanol extract from the seed of Indian soapberry or washnut (*Sapindus mukorossi*), which is rich in saponin, can help in reducing protozoa population in rumen microbes by 52% in buffalo [1]. Their studies also revealed reduction of methane emission of about 20% by using the peppermint (*Mentha piperita*) oil supplemented in wheat straw and concentrate mixture as substrate.
The quality forage also influences the methane emission by the ruminants. The young plants are known to be the better forage due to the presence of higher amount of digestible carbohydrate and less neutral detergent fiber. On the contrary, the change in chemical composition with the rise in carbon and nitrogen levels in the matured forage cause difficulties in digestion, thereby influencing higher methane generation [15]. Mixture of forage and secondary compounds like flowers of some plants are also found to help in inhibiting methanogenesis. Addition of sunflower seed, canola seed, flaxseed, cottonseed, garlic and other oil plants in the diet is also found to be quite effective in reducing methane generation [15]. However, it may be appropriate to have a greater understanding the side effects of any added nutrient on the farm animals and also the long-term adverse impacts on the environment before going for such diet manipulation, even though it has proved to help in methane mitigation. Further, it has also been observed that processing the forages by grinding, chopping or pelleting found to decrease the rumen NDF digestibility and decrease CH_4 emissions due to increased passage rate [20, 28, 22]. Study has shown that silages from maize and whole-crop small-grain produce less CH_4 than grass silage [30, 22]. Further, lower CH_4 emission was observed when alfalfa silage was replaced with 100% corn silage [16].
Plant extracts are found to be an alternative, safe and economical means to reduce methane emission from ruminants [33, 21]. Certain plants extract with high contents of saponins, tannins and essential oils found to inhibit rumen methane production. Study has shown that reduction of enteric methane emission by 17-22% with certain change in the regular feeding practice, i.e. by addition of some commonly available tropical tanniniferous trees leaves *viz*., banyan (*Ficus benghalensis*), jackfruit (*Artocarpus heterophyllus*) and neem (*Azadirachta* indica) at 10% level, without any adverse effect in digestion. Similarly, use of som (*Persea bombycine*) and jamun (*Syzygium cumini*) leaves at 8.5% mixed with the base diet found to reduce 19-21% methane emission of the ruminant livestock. Mixture of 5% of tamarind seed husk with the straw and concentrate based diet also found to reduce 17% of enteric methane emission in cattle without any uncongenial effect on digestion. Further, based on comprehensive studies conducted at ICAR-National Institute for Animal Nutrition and Physiology (NIANP), the institute has developed two anti-methanogenic products i.e. *Tamarin Plus* - an anti-methanogenic feed block containing tamarind seed husk and *Harit Dhara* - an anti-methanogenic feed supplement containing tannins and saponins from natural phyto sources [5], with the later found to reduce the enteric methane emission by 20% when incorporated in livestock feed. A systematic investigation, however, is necessary to

determine appropriate supplementation levels of different plant extracts to assess the maximum retarding effect on enteric methane production [32, 39, 29].

2.2 Breed Selection
The level of methane from livestock is known to be proportional to their body weight and productivity, which is largely influenced also by food and nutrition. While comparing the annual milk yield per animal, Indian diary animals observed to have significantly less milking capacity than those of several developed countries like USA, Netherland, Denmark etc. Therefore, strategies for replacing non-productive and low-productive breeds with higher yielding breeds can reduce methane production for unit production of milk. According to [29] genetic selection based on improved feed efficiency would be able to produce animal having better energy rations thereby producing less methane. [44] concluded that selection of dairy cows capable of high levels of milk production and energy utilization efficiency offers an effective approach to reducing methane emissions from lactating dairy cows. It is a well-known fact that the indigenous breeds of cattle *viz*., Tharparkar, Kankrej, Gir, Sahiwal etc. are more adapted to harsh climatic situations, especially with regard to heat tolerance and disease resistance than those of the cross-bred and exotic ones. Further, it is necessary that greater efforts are given on conservation indigenous livestock breeds and initiation of genetic improvement programme aimed at climate resilience in coming days.

2.3 Innovative Science-led Management
Use of selected strain of live yeast as probiotics, having great functional and metabolic diversity, also shown to reduce methane emission [29]. It may also be appropriate that due research thrust is given to identify specific immunological characters of methanogens through complete genome sequence study. Adoption of certain modern biotechnological tools have also shown to have great potential in methane mitigation. Study has shown that use vaccine against three selected methanogens could reduce the methane emission by 8% in Australian sheep [43, 29], thus showing the potential of such futuristic technologies as a methane mitigation measure.

2.4 Waste Management
In India, large percent of the ruminants are owned by small, marginal and land-less farmers, which graze on rangelands, where methane emissions from their faeces is considered to be very less. Methane is known to be a potent greenhouse gas and also a valuable source of energy. During the disposal of dung along with liquid usually the anaerobic conditions arise. In such anaerobic decomposition, when the manure is stored or treated as a liquid in tanks or pits, the process significantly influences the methane emissions. The manure management through biogas plants can help in methane recovery which can be used for energy generation [18, 31]. The degree of methanogenesis is also depended on the temperature and the duration of retention in storage tank/container [25]. Handling of the dung in solid form i.e. in stacks/heap or deposition in pasture and rangelands shown to accelerate its aerobic decomposition and hence suggested as measures for reduction of methane production by the authors. [7] reported a decline of 30-50% methane production with the reduction of storage temperature of manure. The net methane reduction from this strategy, however, vary widely, which is largely depend on the energy used and the adopted cooling system.

Strategic use of methane in the biogas system can not only help in reduction of methane emission but also save the fossil fuel thereby strengthening the economy [6]. Recycling the bio-waste through adoption of new technologies like vermiculture and its safe disposal within a short period is another important approach for mitigation of methane instead of following the traditional method of recycling the farm waste.

3. Conclusion
Amelioration of methane emissions from livestock system essential not only for the climate change and global warming but also for saving dietary energy. The suggested mitigation strategies *viz*., reducing livestock population and replacement with high-yielding breeds against low productive animals to maintain the production growth trend, focus on improved genetic selection, dietary manipulation, ensuring effective health management of animals with necessary vaccines and use of other advanced technology preventing/reducing methane generation and using the potential of methane as biogas, etc. would go long way in reducing the methane emission from the livestock sector. Awareness generation and extension are important means towards the adoption of improved technological practices. Extensive training programmes and farm demonstration in this context are considered to be of high relevance. Further, greater research and development support is very much essential to investigate further prospects of amelioration of methane emission which are appropriate, cost-effective and practicable. Further, it is also necessary to have strong policy narratives for each of the country to strategize the reduction of the total methane emission from the livestock sector, which would have a great bearing in combating global climate change impacts.

4. References

1. Agarwal N, Shekhar C, Kumar R. Effect of peppermint (*Mentha piperita*) oil on *in vitro* methanogenesis and fermentation of feed with buffalo rumen liquor. Animal Science and Technology. 2009; 48:321-327.
2. Agrawal DK, Kamra DN. Global warming: Role of livestock and mitigation strategies. In: International Conference on Physiological capacity building in livestock under changing climate scenario. Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, India, 2010, 27-39.
3. Bannink A, van Schijndel MW, Dijkstra J. A model of enteric fermentation in dairy cows to estimate methane emission for the Dutch National Inventory Report using the IPCC Tier 3 Approach. Animal Feed Science and Technology. 2011; 166-167:603-618.
4. Beauchemin KA, McAllister TA, McGinn SM. Dietary mitigation of enteric methane from cattle. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources. 2009; 4:1-18.
5. Bhatta R, Malik PK, Sejian V. Livestock production and climate change: methane and stress amelioration. In: Transfer of Mitigation Technologies for Heat Stress in Farm Animals, Eds. Sejian V, Chauhan SS, Malik PK, Krishnan G, Bagath M, Kolte AP and Bhatta R. Proc. of Indo-Australian Workshop on Transfer of Mitigation Technologies for Heat Stress in Farm Animals. ICAR-NIANP, Bengaluru, India, 2020, 33-43.
6. Biogas Opportunities Roadmap. Voluntary Actions to

Reduce Methane Emissions and Increase Energy Independence, U.S. Department of Agriculture, U.S. Environmental Protection Agency, U.S. Department of Energy, 2014.
7. Borhan MS, Mukhtar S, Capareda S, Rahman S. Greenhouse gas emissions from housing and manure management systems at confined livestock operations. In: Waste Management - an Integrated Vision, Chapter 12. Rebellon LFM (Eds). Rijeka (Croatia): In Tech. 2012, 259-296. doi.org/10.5772/51175.
8. Broucek J. Options to methane production abatement in ruminants: a review. The Journal of Animal & Plant Sciences. 2018; 28(2):348-364.
9. Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J *et al*. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome, 2013.
10. Giger-Reverdin S, Morand-Fehr P, Tran G. Literature survey of the influence of dietary fat composition on methane production in dairy cattle. Livestock Production Science. 2003; 82:73-79.
11. Goel G, Makkar HPS. Methane mitigation from ruminants using tannins and saponins. Tropical Animal Health and Production. 2012; 44(4):729-739.
12. Government of India. First Biennial Update Report to the United Nations Framework Convention on Climate Change, Ministry of Environment, Forest and Climate Change, Government of India, 2015.
13. Grainger C, Beauchemin KA. Can enteric methane emissions from ruminants be lowered without lowering their production? Animal Feed Science and Technology, 2011; 166-167:308-320.
14. Grossi G, Goglio P, Vitali A, Williams AG. Livestock and climate change: impact of livestock on climate and mitigation strategies. Animal Frontiers. 2019; 9(1):69-76.
15. Haque NM. Dietary manipulation: a sustainable way to mitigate methane emissions from ruminants. Journal of Animal Science and Technology. 2018; 60:15.
16. Hassanat F, Gervais R, Julien C, Massé DI, Lettat A, Chouinard PY *et al*. Replacing alfalfa silage with corn silage in dairy cow diets: Effects on enteric methane production, ruminal fermentation, digestion, N balance and milk production. Journal of Dairy Science. 2013; 96(7):4553-4567.
17. IPCC. Report of the Twelfth Season of the Intergovernmental Panel on Climate Change, Intergovernmental Panel on Climate Change (IPCC), Mexico City, 1996, 11-13.
18. Jha AK, Singh K, Sharma C, Singh SK, Gupta PK. Assessment of methane and nitrous oxide emissions from livestock in India. Journal of Earth Science Climate Change. 2011; 2(1):107.
19. Johnson KA, Johnson DE. Methane emissions from cattle. Journal of Animal Science. 1995; 73(8):2483-2492.
20. Johnson DE, Ward GM, Ramsey JJ. Livestock methane: Current emissions and mitigation potential**.** In: Nutrient Management of Food Animals to Enhance and Protect the Environment Kornegay ET (Ed.). Lewis Publishers CRC Press Inc., Boca Raton, FL, 1996, 219-233.
21. Kim ET, Kim CH, Min KS, Lee SS. Effects of plant extracts on microbial population, methane emission and ruminal fermentation characteristics in *in vitro*. Asian-Australasian Journal of Animal Science. 2012; 25:806-811.
22. Knapp JR, Laur GL, Vedas A, Weiss WP, Tricarico JM. *Invited review:* Enteric methane in dairy cattle production: Quantifying the opportunities and impact of reducing emissions. Journal of Dairy Science. 2014; 97(6):3231-3261.
23. Lovett D, Lovell S, Stack L, Callan J, Finlay M, Conolly J *et al*. Effect of forage/concentrate ratio and dietary coconut oil level on methane output and performance of finishing beef heifers. Livestock Production Science. 2003; 84:135-146.
24. Lozano MG, Yadira PG, Abigail K, Arellano A, arlos LO, Balagurusamy N. Livestock methane emission: microbial ecology and mtigation strategies. In: Livestock Science, Selim Sekkin (Ed.), InTech, 2017. doi: 10.5772/65859.
25. Malik PK, Kolte AP, Dhali A, Sejian V, Thirumalaisamy G, Gupta R *et al*. GHG emissions from livestock: Challenges and ameliorative measures to counter adversity. In: Greenhouse Gases - Selected Case Studies, Chapter 1, InTech. Janeza Trdine, Rijeka, Croasia, 2016, 1-16.
26. Martin C, Morgavi D, Doreau M. Methane mitigation in ruminants: from microbe to the farm scale. Animal. 2010; 4(3):351-365.
27. Mihaela G, Criste A, Cocan D, Constantinescu R, Raducu C, Miresan V. Methane production in the rumen and its influence on global warming. Pro-Environment. 2014; 7:64-70.
28. Moss AR, Jouany JP, Newbold J. Methane production by ruminants: its contribution to global warming. Annales de zootechnie, INRA/EDP Sciences. 2000; 49(3):231-253.
29. Moumen A, Azizi G, Chekroun BK, Baghour M. The effects of livestock methane emission on the global warming: a review. International Journal of Global Warming. 2016; 9(2):229-253.
30. O'Mara FP, Fitzgerald JJ, Murphy JJ, Rath M. The effect on milk production of replacing grass silage with maize silage in the diet of dairy cows. Livestock Production Science. 1998; 55:79-87.
31. Owen JJ, Silver WL. Greenhouse gas emissions from dairy manure management: a review of field-based studies. Global Change Biology. 2014. doi: 10.1111/gcb.12687
32. Patra AK, Saxena J. Dietary phytochemicals as rumen modifiers: a review of the effects on microbial populations. Antonie van Leeuwenhoek. 2009; 96(4):363-375.
33. Patra AK, Saxena J. A new perspective on the use of plant secondary metabolites to inhibit methanogenesis in ruminants. Phytochemistry. 2010; 71(11):1198-1222.
34. Patra AK. Trends and Projected Estimates of GHG Emissions from Indian Livestock in Comparisons with GHG Emissions from World and Developing Countries. Asian-Australasian Journal of Animal Science. 2014; 27(4):592-599.
35. Patra A, Park T, Kim M, Yu Z. Rumen methanogens and mitigation of methane emission by anti-methanogenic compounds and substances. Journal of Animal Science and Biotechnology. 2017; 8:13.
36. Rojas-Downing MM, Nejadhashemi AP, Harrigan T, Woznicki SA. Climate change and livestock: Impacts, adaptation, and mitigation. Climate Risk Management.

2017; 6:145-163.
37. Sejian V, Naqvi SM. Livestock and climate change: mitigation strategies to reduce methane production. In: Greenhouse Gases - Capturing, Utilization and Reduction, Liu G (Ed.), InTech, 2012; 11:255-276. DOI: 10.5772/32014.
38. Sejian V, Bhatta R, Malik PK, Madiajagan B, Al-Hosni YAS, Sullivan M *et al*. Livestock as sources of greenhouse gases and its significance to climate change, greenhouse gases, Bernardo Llamas Moya and Juan Pous. Intech Open, 2016. DOI: 10.5772/62135.
39. Shibata M, Terada F. Factors affecting methane production and mitigation in ruminants. Animal Science of Journal. 2010; 81(1):2-10.
40. Singh CK, Anand Kumar, Roy SS. Quantitative analysis of the methane gas emissions from municipal solid waste in India. Scientific Reports. 2018; 8:2913.
41. Sparkling C, Cone JW, Pellikaan W, Hendriks WH. Utilization of rice straw and different treatments to improve its feed value for ruminants: a review. Asian-Australasian Journal of Animal Science. 2010; 23:680-692.
42. Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, de Haan C. Livestock's Long Shadow. Food and Agriculture Organization of the United Nations. Rome, 2006.
43. Wright ADG, Kennedy P, O'Neill CJ, Toovey AF, Popovski S, Rea SM *et al*. Reducing methane emissions in sheep by immunization against rumen methanongens. Vaccine. 2004; 22:3976-3985.
44. Yan T, Mayne CS, Gordon FG, Porter MG, Agnew RE, Patterson DC *et al*. Mitigation of enteric methane emissions through improving efficiency of energy utilization and productivity in lactating dairy cows. Journal of Dairy Science. 2010; 93(6):2630-2638.
45. Zhang X, Medrano RF, Wang M, Beauchemin KA, Ma Z, Wang R *et al*. Effects of urea plus nitrate pretreated rice straw and corn oil supplementation on fiber digestibility, nitrogen balance, rumen fermentation, microbiota and methane emissions in goats. Journal of Animal Science and Biotechnology. 2019; 10:6.
46. Capareda S, Rahman S. Greenhouse gas emissions from housing and manure management systems at conned live-stock operations. In: Rebellon, L. F. M., editors. Waste management—an integrated vision. Rijeka (Croatia): In Tech, 2012, 259-296. doi:10.577