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GUEST EDITORIAL

Issue of enteric methane emissions from Indian livestock

The issue of greenhouse gas (GHG) emissions and its impact on climate change is a matter of imperative concern at the global level. Livestock farming has long been a mainstay of human civilization, providing essential food and other resources to humankind. Ramifications of the livestock industry, especially its effects towards GHG emissions, cannot be overlooked in this context. While the transport and energy production industries are in the centre stage for their GHG emissions, the spotlight on the livestock industry often gets relegated. However, livestock production too plays a vital role in contributing to the peril of GHG emissions. Methane is a potent GHG, which is latent but has a significantly higher potential than carbon dioxide over a 20-year time frame. Due to its relatively lower concentration in the atmosphere, its impact often gets underestimated. Therefore, we must appraise the issue's intensity, emphasize the dire need to address the same and initiate proactive measures to mitigate GHG emissions from livestock.

Natural and anthropogenic sources, together, emit about 558 Tg (teragrams) of methane, of which 188 Tg arises from agricultural waste due to anthropogenic activities. Due to various sinks in the atmosphere and soil, 548 Tg of this methane emission is removed, building up the atmospheric methane pool by 10 Tg every year. It is reckoned that globally, livestock is accountable for 15% of anthropogenic GHG emissions, which is more than the entire transport sector combined (Gerber, P. J. *et al.*, *Animal*, 2013, **7**(2), 220–234; doi:10.1017/S1751731113000876). Livestock farming, the production of particularly beef and dairy products, contributes to GHG emissions significantly. Methane and nitrous oxide are potent GHGs released during enteric fermentation (digestion) and manure management respectively. Methane is the second most significant greenhouse gas in the atmosphere (Yusuf, R. O. *et al.*, *Renew. Sustain. Energy Rev.*, 2012, **16**(7), 5059–5070; doi:10.1016/j.rser.2012.04.008).

The atmospheric concentration of methane is about 1889 ppb, which is increasing at an average rate of 10 ppb every year (Dlugokencky, 2021, https://gml.noaa.gov/ccgg/trends). Enteric fermentation, with an annual emission of 87–97 Tg, remains one of the largest sources of methane in the agriculture sector (Chang, J. *et al.*, *Nature Commun.*, 2019, **10**, 3420), wherein cattle and buffaloes contribute 77% and 13% respectively, to global enteric methane emissions (FAO, GHG Emissions by Livestock, 2021). In addition to contribution to global warming, enteric methane is also responsible for a substantial loss of 2–12% of dietary energy (Johnson, K. A. and Johnson, D. E., *J. Anim. Sci.*, 1995, **73**, 2483–2492), as each litre of enteric methane emission carries 39.5 kJ of dietary energy away from the animal (Guan, H. *et al.*, *J. Anim. Sci.*, 2006, **84**, 1896–1906; https://doi.org/10.2527/jas.2005-652, PMID: 16775074). Energy is one of the most expensive items obtained from various fractions, such as carbohydrates, fat and proteins in the diet. Energy loss from Indian livestock in the form of methane is crucial as the country is in a severe deficit of energy availability against the livestock requirement. According to estimates by the ICAR-National Institute of Animal Nutrition and Physiology (NIANP), about 23% of Total Digestible Nutrients (TDN) – a measure of feed energy, is the deficit against the requirement.

On several international and national platforms, Indian livestock resources are often recriminated of high enteric methane emission. Enteric methane emission from Indian livestock is generally over-estimated due to dependency on a single equation followed by the Inter-governmental Panel on Climate Change (IPCC). Use of IPCC tier systems (I and II), due to the seasonal and regional variability in the availability of feed resources in the country and variable methane emission, even at similar intakes, usually lead to uncertainty in the enteric methane emission estimation from Indian livestock. Accurate estimation of methane emission is, however, an obligation for better understanding the extent of livestock contribution to climate change, establishing emission reduction targets, developing effective mitigation strategies, formulating incentive programmes for sustainable farming practices and enabling policymakers to devise suitable environmental regulations. This would also help the country in fulfilling its obligation of net-zero carbon emission by 2070.

Considering the uncertainty in the enteric methane emission estimates and over-estimated figures from Indian livestock, the NIANP developed a relatively accurate inventory of the state-wise enteric methane emissions from the Indian ruminant animals. Unlike the previous estimates, the inventory developed by the NIANP has taken into account the seasonal and regional variability in feed resources, feeding practices, physiological stages of animals, etc. More significantly, the inventory is based on the primary data on the methane production potential of more than 1500 feed ingredients/diet combinations and prevailing feeding practices. This has revealed that the Indian livestock annually emits about 9.25 Tg enteric methane. Five states, namely Andhra Pradesh (undivided), Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh, together contribute to almost half of the total enteric methane emission. While AP, MP, Maharashtra and Rajasthan respectively, account for 0.73, 0.79, 0.70 and 0.81 Tg of annual enteric methane emission, UP is the largest emitter contributing 1.52 Tg. The database also indicates that amongst different species, cattle emit 56%, buffaloes 29%, sheep 5% and goats 10%.

One potential option for mitigating enteric methane emission is to gradually reduce unproductive or low-producing animals by culling. However, due to religious and social issues, bringing down the cattle population by culling seems not plausible at present in the country. In the last two decades, scientists in ICAR have tasked perpetually with quantifying enteric methane emissions from different livestock species and exploring viable options for curtailing methane emissions. Researchers have attempted numerous approaches, and after a series of *in vitro* and animal studies, they have developed promising, farmer-friendly methane mitigation technologies requiring low inputs. Among them, the feed-based approach has proved to be a workable and realizable option. Some of the proven, low-cost technologies developed in the country, which lead to an average reduction of 20% in daily enteric methane emissions, are ration balancing, feeding of tree leaves, use of anti-methanogenic products, seaweeds and biowaste.

Ration balancing with the locally available feed resources at the farmers' doorsteps appears to be an effective and easier way to mitigate methane emission up to the desirable extent of 20%. The National Dairy Development Board (NDDB) and National Dairy Research Institute (NDRI) have proved under the Ration Balancing Programme in different agro-climatic regions that a moderate reduction of 10–15% can be achieved by balancing the ration with feed ingredients available with the farmers (Garg, M. R. *et al.*, *Indian J. Dairy Sci*., 2012, **65**(3), 250–255).

Tree leaves are rich in plant secondary metabolites such as tannins, saponins and essential oils. Studies carried out by NIANP (Bhatta, R. *et al*., *J. Appl. Microbiol*., 2015, **118**(3), 557–564; https://doi.org/10.1111/jam.12723 and Malik, P. K. *et al.*, *Livest. Sci.*, 2017, **200**, 29–34) have established that inclusion of tropical tree leaves such as jack fruit, neem and banyan at 5% in the diet effectively decreases enteric methane emissions without affecting feed fermentation in the rumen. Similarly, som leaves in the north-east and jamun leaves are also found to be effective in reducing daily methane emissions by up to 15% (Baruah, L. *et al*., *Carbon Manage.*, 2019, **10**, 299–308; https://doi.org/10.1080/17583-004.2019.1605480).

After systematic *in vitro* and animal studies, scientists at NIANP have developed an anti-methanogenic feed supplement named 'Harit Dhara'. This product has been evaluated for reduced daily enteric methane emissions and impact on the productivity of the farmers' dairies. Keeping in view the economic status of our farmers, 'Harit Dhara' was formulated using affordable and abundant phyto-materials so that it can be easily fed. When fed to ruminants (cattle, buffaloes, sheep and goats), it is found to be quite effective in reducing the daily enteric methane emission by about 20% (Malik, P. K. *et al*., *Front. Microbiol.*, 2022, **13**, 1048288). It is, however, not recommended for intake of animals below 3–4 months of age, as the rumen would not be fully functional at that stage. The daily reduction in enteric methane emissions due to the feeding of 'Harit Dhara' in cattle and buffaloes is equivalent to 700–800 litres of CO_2. The use of 'Harit Dhara' would also lead to a daily increase of about 300–500 ml of milk production, in addition to environmental benefits. The benefit-to-cost ratio with feeding 'Harit Dhara' is about 1 : 5 in lactating dairy animals and about 1 : 4 in growing sheep.

Seaweeds, popularly known as macro algae, have the potential to reduce enteric methane emissions. Recently, researchers have established that the red algae *Asparagopsis taxiformis*, to a great extent, inhibits methanogenesis. Bioactive compounds in seaweeds are primarily responsible for the reduction in enteric methane emissions. It is estimated that India, with a coastline of 8129 km, possesses about 844 species of seaweeds (including 434 red, 194 brown and 216 green species). Preliminary studies at the NIANP have established that the biowaste of brown algae *Padina gymnospor*, obtained after super-critical fluid extraction from the nutraceutical industries, has the potential to inhibit methanogenesis. However, due to low biomass yield, high bromoform, heavy metals and iodine content, caution is required to use this algae to reduce methane production.

The urgency of intercepting enteric methane emissions from livestock needs to be emphasized. Adopting farmer-friendly and affordable technologies would have multiple benefits in attaining a desirable reduction of 15–20% in daily enteric methane emissions. This would not only contribute to our commitment to attainable zero-carbon emissions by 2070 but also would improve the economic progress of dairy farmers through production and productivity enhancement.

Adopting a single approach across the country as a mitigation strategy may not work out, given various known and unknown factors. Therefore, devising multiple, region and season-specific approaches and different prongs could prove to be viable options in addressing this critical issue.

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