Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(3): 113-116

Received: 26-03-2020
Accepted: 27-04-2020

Jyotsnarani Biswal
Scientist, International Livestock Research Institute, South Asia Regional Office, New Delhi, India

Kennady Vijayalakshmy
Scientist, International Livestock Research Institute, South Asia Regional Office, New Delhi, India

Habibar Rahman
Regional Representative for South Asia, International Livestock Research Institute, South Asia Regional Office, New Delhi, India

Corresponding Author:
Kennady Vijayalakshmy
Scientist, International Livestock Research Institute, South Asia Regional Office, New Delhi, India

Impact of methane emission and associated environmental stress on livestock production systems in India

Jyotsnarani Biswal, Kennady Vijayalakshmy and Habibar Rahman

Abstract

Livestock farming in India is one of the significant anthropogenic sources of methane (CH_4) emission. The present study as an effort to review and analyze the present status of methane emission by the Indian livestock. The anaerobic conditions of the large fore stomach of the rumen lead to release of methane as a by-product from the digestive system, which shares about 90% of the methane contributed by livestock, with other 10% generated through reaction from manure heaps. The impact of the climate change on the livestock productivity, breeding performance and disease threats has also been highlighted.

Keywords: Climate change, environmental stress, greenhouse gases, livestock, methane emission

Introduction

The increasing concentration of greenhouse gases (GHG) in the atmosphere, largely leading to the phenomenon of climate change, has been a major concern of whole world today. Carbon dioxide (CO_2), methane (CH_4) and Nitrous oxide (N_2O) have been the major greenhouse gases contributed from the anthropogenic sources. It is the activity of incoming and outgoing GHG which are leading to the warming and cooling of earth surface respectively. Although increasing GHG production has been posing threat to the life on the universe, it is also recognized that their absence would lead to bring down the average temperature of earth's surface to about -18°C [1]. Therefore, for survival of life on earth, the heating effect is vital. However, it is the rapid increase in the concentration of these gases which are causing the impact of climate change and also global warming. Atmospheric methane (CH_4) has been recognized the second most important greenhouse gas, only after CO_2, playing significant role in global warming and climate change, executing the photochemistry of the troposphere and stratosphere.

At present, methane contributes about 20% of anthropogenic radiative, only after carbon dioxide at 60% [2]. However, as it is about 25 times more potent in trapping atmospheric heat than the CO_2, it has perceived greater concern over these years. However, comparatively low persistence period of about 10 years, compared to thousands of years in case of CO_2 in the atmosphere, has led to increased global attention for implementing the emission reduction programmes for the methane. The human-related activities, predominantly agriculture and fossil fuel use, are pointed at increasing trend of methane concentration [3]. While the natural sources estimated to contribute about 40% of the global methane emissions and among them wetlands, termites and oceans have been the primary sources; the anthropogenic interventions contribute 64% of the total [4]. Application of organic and inorganic inputs to the soil, decomposition of biomass and plant residues, crop production and livestock rearing have been the principal sources of emissions from agriculture [5]. Within agriculture sector livestock is contributing to a major share of methane, emitted mainly by two processes i.e. enteric fermentation and manure management. Further, the quantity of methane generation also depends on the type of animal, kind and amount of consumed feed and the nature of waste management.

Methane Emission associated with livestock production systems

Globally, the livestock sector contributes to the livelihoods of over one billion poorest population and employs as many as 1.1 billion people [6]. Further, the livestock products, viz., milk and meat are recognized as the important agricultural commodities for global food and nutritional security, and providing 33% of global protein consumption [7]. In India, livestock production system has been an important component of allied agriculture and is continued to be a major means of livelihood in the rural fronts, and assuring nutrition, income and employment. Its share to the agricultural GDP in the country has been on the gradual rise over the years. It is estimated that livestock contributes about 27% to the country's agricultural GDP and employs 8% of the labour force. With 535 million livestock population at present (20th National Livestock Census), India ranks first i.e. about 13% of the world's total livestock population. It ranks first with regard to the bovine (cattle and buffalo), second in goat and third in sheep populations in the world.

There are significant differences in the methane emissions calculated by different approaches, thereby emphasizing the requirement for further verification for the country. $EDGAR_{2010}$ (Emissions Database for Global Atmospheric Research v4.2 FT 2010) estimated India's anthropogenic emissions to be 29.6 Tg/yr with ~44%, 20%, 19% and 12% of which contributed by ruminants, waste (solid and wastewater), rice paddies and fossil fuels, respectively. According to the BUR (Biennial Update Report) of India to the United Nations Framework Convention on Climate Change (UNFCCC) in 2010, the total emissions were reported as 19.8 (13.6–26.0) Tg/yr, with ruminants contributing as much as 55%, followed by rice (17%), fossil fuel (13%) and waste (12%). To quantify the methane emissions from India between 2010 and 2015 and to investigate sources of discrepancies between the two inventories ($EDGAR_{2010}$ and BUR), [8] used a combination of aircraft (passenger aircraft observations from CARIBIC - Civil Aircraft for the Regular Investigation of the atmosphere Based on an Instrument Container), satellite (GOSAT - Greenhouse Gases Observing Satellite) and surface observations and estimated the average emissions to be 22.0 (19.6–24.3) Tg/yr using the approach of a high-resolution regional atmospheric transport model and a hierarchical Bayesian inverse modelling framework. Although these emissions data were similar to the India's reports to the UNFCCC but were about 30% lesser than the global methane inventory, $EDGAR_{2010}$). According to [9], the agriculture sector (enteric fermentation, manure management, rice cultivation) accounts for 61% of the total methane emissions in India, with 40% coming from enteric fermentation, 17% from rice cultivation and 4% from manure management.

The rumen, a large fore stomach, which under anaerobic conditions produces methane as a by-product of the feed digestion system, with a continuous process of fermentation [10]. Methanogenesis, also known as biomethanation, is a microbial metabolic process of anaerobic respiration of formation of methane with reduction of carbon dioxide (CO_2) by hydrogen (H_2) with help of the methanogen microbes viz., bacteria, viruses, fungi, protozoa and others. Estimation of methane emission by various studies indicate wide variations in the output by the Indian livestock, as most of these are based on theoretical calculations and without any systematic experiments [11]. In general, cattle and buffalo produce about 200-250 liter and sheep and goat produce about 30-40 liter of methane per day [12].

Enteric methane emission was found to be about 10.08 Tg/yr in 1994 [13]. Using the livestock census of 2003 with population of 485 million and country-specific Indian feed standard based emission coefficients, [14] had estimated total enteric methane emission of 10.65 Tg/yr, which accounted ~91% of the total methane emissions and manure management of livestock accounted for only 9% or 1.09 Tg/yr. According to them, out of total methane emission of 11.75 Tg/yr from the livestock, cattle and buffalo are the major contributor (10.9 Tg/yr) compared to 0.86 Tg/yr emission from other livestock. The three high methane emitter states are Uttar Pradesh (14.9%), Rajasthan (9.1%) and Madhya Pradesh (8.5%). Following different approaches, [15] estimated the enteric methane emission ranging 9.0-13.2 Tg/yr from the Indian livestock with the base year as 1997. Further, [16] estimated enteric methane emission of 14.3 Tg/yr for the year 2010 and projected the same to be 15.8 Tg/yr and 18.8 Tg/yr by 2025 and 2050 respectively. As per his estimate, cattle rank first in contributing enteric methane emission of about half (49.1%) of total enteric methane, followed by buffalo (42.8%), goat (5.38%), sheep (2.59%) and others (0.73%).

Using a dynamic approach based on the STELLA software along with a developed mathematical models, [17] estimated methane emissions in India for a 25 year period (2007-2032) under six different scenarios following IPCC emission guidelines. Under modified scenarios the results indicated the emissions range from 13.85 Tg/yr in 2007 to 16.62 Tg/yr in 2032. The highest emission was observed in buffalo (1155 kg CO_2e CH_4/head/yr) followed by cattle (672 kg CO_2e CH_4/head/yr) and goats and sheep (105 kg CO_2e CH_4/head/yr) in all scenarios.

ICAR-NIANP in collaboration with several partner organizations recently has developed a state-wise inventory of enteric methane emission from livestock of the country which showed to be 9.253 Tg [18]. The study showed that Uttar Pradesh (16.42%), Rajasthan (8,75%), Madhya Pradesh (8.54%), undivided Andhra Pradesh (7.87%) and Maharashtra (7.57%) to be major contributor to the country's total enteric methane emission.

The emission of methane also taken place through reaction from manure heaps, which is similar to enteric fermentation. The cellulose content of the manure is degraded by the microbes in the process of methanogenesis [19]. Manure generated from livestock production systems is generally dumped as such at one place in solid form before transferred to the agricultural land. Low digestibility of dietary nutrients may subject to generation of higher amount of fermentable organic matter in the manure, which can lead to increased production methane in the manure. Sometimes, the wastes are also subjected to composting before application in agriculture land or digested anaerobically to produce methane gas to be used as biofuel for cooking. Annual methane emissions from manure management from Indian livestock were estimated through several studies, viz., 0.91 Tg/yr in 1997 [15] and 1.13 Tg/yr in 2010 [16].

Although livestock farming system is accused as major reason for anthropogenic source of methane emissions, research results have shown that the intensive rice cultivation in the hot climate with continuous water flooding is also a great source of methane emission, caused through anaerobic decomposition of organic material [20] and burning of huge quantity of the straw. In India, methane emission is also observed to be on increase in the months of June-September coinciding with paddy harvesting.

Impact of environmental stress on livestock production

The most significant direct impact of climate change on livestock production has been the heat stress, which largely lead to reduction in reproductive efficiency, increase in disease incidence, and reduction in growth of the animals and milk production, resulting in significant economic loss to the livestock keepers. It is envisaged that the scenario is likely to be more pronounced in coming years. The climate change event like drought also likely to incur indirect impacts on the livestock production systems through reduced availability of feed and fodder, and also water. Extremely high temperature coupled with high humidity or intense heat waves results in high production losses and sometimes also death of the livestock.

Increase of environmental temperature would lead to increase in number of stressful days (Temperature Humidity Index, THI > 80), affecting milk production in dairy animals. Further, it is envisaged that the productive animals are likely to be affected much more [21]. The study showed decline in milk yield varied from 10-30% in first lactation and 5-20% in subsequent lactation period in Murrah buffaloes. Further, according to their estimate the annual loss due to direct thermal stress on livestock is about 1.8 million tonnes of milk, i.e. about 2% of the country's total milk production. The performance of Holstein cattle crossed with local cattle breeds in tropics and subtropics found to be more resistant to the heat stress over the pure breed of Holstein cattle [22]. Heat stress has been found to be associated with increase in embryonic mortality and impairment of embryo development in cattle. Further, during pregnancy period it slows down the growth of fetus and may lead to increase fetal loss.

The substantial variation in precipitation and extreme weather events mediated by climate change have increased the chance of emergence of new pathogenic microbial strains, leading to incidence of new disease outbreaks in livestock and poultry. Re-emergence of certain animal diseases, besides spreading of temperate ones to tropical regions and *vice versa* have also been reported in recent years. The unusual change in temperature and humidity scenario likely to impact on the transmission vectors such as mosquitoes, flies, lice, mites and ticks and thereby the epidemiology of several of the vector-borne diseases [23]. The spread of diseases like Avian Influenza and Swine Flu is also expected to be mediated by the climate change impacts, largely impacting the production systems and also overall economy of the farmers.

Conclusion

Livestock sector in India has emerged as an important engine for steady agricultural growth and enhancing income of the famers. The sector has long been a crucial driver of employment generation and livelihood opportunities. Further, the population dependent on livestock sector is growing faster in comparison to agriculture sector. In order to meet the ever-increasing demand of food and achieving nutrition from animal source there have been substantial growth in livestock population over the years, leading to increase in methane emission levels, not only in the country but also globally. The harmful impact of methane emission to the environment has been a global concern, which although is not possible to eliminate, however, can be substantially reduced through having appropriate balance of livestock population and following different scientific mitigation strategies and thereby reducing the overall greenhouse generation and also climate change impacts.

References

1. Qiancheng MA. Greenhouse gases: refining the role of carbon dioxide. Science Briefs, The National Aeronautics and Space Administration (NASA), Goddard Institute of Space Studies, 1998. https://www.giss.nasa.gov/research/briefs/ma_01/
2. Lassey KR. Livestock methane emission: from the individual grazing animal through national inventories to the global methane cycle. Agricultural and Forest Meteorology. 2007; 142(2):120-132.
3. IPCC (Intergovernmental Panel on Climate Change). Climate Change: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (Eds). Cambridge University Press, Cambridge, UK, and New York, USA, 2001, 1032.
4. World Meteorological Organisation. Greenhouse gas concentrations in atmosphere reach yet another high. Press Release Number: 25112019, 2019. https://public.wmo.int/en/media/press-release/greenhouse-gas-concentrations-atmosphere-reach-yet-another-high
5. IPCC (Intergovernmental Panel on Climate Change). Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA (Eds). Cambridge University Press, Cambridge, United Kingdom and New York, USA. 2007, 851 pp.
6. Hurst P, Termine P, Karl M. Agricultural workers and their contribution to sustainable agriculture and rural development. FAO, Rome, 2005.
7. Rosegrant MW, Ringler C, Zhu T. Water for agriculture: maintaining food security under growing scarcity. Annual Review of Environment and Resources. 2009; 34:205-222.
8. Ganesan Anita L, Rigby M, Mark Lunt F, Robert Parker J, Hartmut Boesch N, Goulding Taku U *et al*. Atmospheric observations show accurate reporting and little growth in India's methane emissions. Nature Communications. 2017; 8(836).
9. Garg A, Kankal B, Shukla PR. Methane emissions in India: sub-regional and sectoral trends. Atmospheric Environment. 2011; 45:4922-4929.
10. Broucek J. Production of methane emissions from ruminant husbandry: A review. Journal of Environment Protection. 2014; 5:1482-1493.
11. Singh GP, Mohini M. Methane emission by Indian ruminant livestock, Current Science. 1996; 71(7):580-582.
12. Trivedi S, Malik PK, Kolte AP, Thirumalaisamy G, Sejian V, Bhatta R. Relevance of unrevealing methanogen diversity to reduce methane emission from Indian livestock. In: Transfer of Mitigation Technologies for Heat Stress in Farm Animals. Sejian V, Chauhan SS, Malik PK, Krishnan G, Bagath M, Kolte AP, Bhatta R (Eds). Proceedings of Indo-Australian Workshop on Transfer of Mitigation Technologies for Heat Stress in Farm Animals. ICAR-NIANP, Bengaluru, India, 2020, 143-146.
13. Singhal KK, Mohini Madhu, Jha Arvind K, Gupta Prabhat K. Methane emission estimates from enteric fermentation in Indian livestock: Dry matter intake approach. Current Science. 2005; 88(1):119-127.
14. Chhabra A, Manjunath KR, Panigrahy S, Parihar JS. Spatial pattern of methane emissions from Indian livestock. Current Science. 2009; 96(5):683-689.
15. Swamy M, Bhattacharya S. Budgeting anthropogenic

greenhouse gas emission from Indian livestock using country-specific emission coefficients. Current Science. 2006; 91:1340-1353.

16. Patra AK. Trends and Projected Estimates of GHG Emissions from Indian Livestock in Comparisons with GHG Emissions from World and Developing Countries. Asian-Australasians Journal of Animal Sciences. 2014; 27(4):592-599.
17. Shilpi Kumari, Dahiya RP, Naik SN, Hiloidhari Moonmoon, Thakur Indu Shekhar, Sharawat Isha *et al*. Projection of methane emissions from livestock through enteric fermentation: A case study from India. Environmental Development. 2016; 20:31-44.
18. 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. Proceedings of Indo-Australian Workshop on Transfer of Mitigation Technologies for Heat Stress in Farm Animals. Sejian V, Chauhan SS, Malik PK, Krishnan G, Bagath M, Kolte AP, Bhatta R (Eds). ICAR-NIANP, Bengaluru, India, 2020, 33-43.
19. Chianese DS, Rotz CA, Richard TL. Whole farm greenhouse gas emissions: A review with application to a Pennsylvania Dairy Farm. Applied Engineering in Agriculture. 2009; 25:431-442.
20. Shalini Ananda, Dahiyaa RP, Talyana Vikash, Vratb Prem. Investigations of methane emissions from rice cultivation in Indian context. Environment International. 2005; 31:469-482.
21. Upadhyay RC, Singh SV, Kumar A, Gupta SK, Ashutosh. Impact of climate change on milk production of Murrah buffaloes. Italian Journal of Animal Sciences. 2007; 6(2):1329-1332.
22. Molee A, Bundasak B, Petladda K, Plern M. Suitable percentage of Holstein in crossbred dairy cattle in climate change situation. Journal of Animal and Veterinary Advances. 2011; 10(7):828-831.
23. Thornton P, Steeg van de J, Notenbaert A, Herrero M. The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. Agricultural Systems. 2009; 101(3):113-127.