Ruminant and environment: A review

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ABSTRACT

Major green house gases are carbon dioxide, methane, and nitrous oxide which are emitted directly and indirectly by ruminants. More than 80 per cent methane is normally produced during enteric fermentation. Methane has the second largest contributor to the greenhouse effect and has 23 times more global warming potential than carbon dioxide. The Indian contribution of methane from all sources is around 12 per cent of total world production, in which mostly by emission by ruminants. India possesses largest ruminant population. An effort is made to mitigate the methane production in the ruminants. Nutritional management like good quality feed, use of higher concentrates, supplementing cattle diets with urea molasses block licks, fiber palleatization, breeding management like AI., ETT, In vitro fertilization which improves genetics and reproductive efficiency can also improve production efficiency which reduces greenhouse gas emission.

Key words: Enteric fermentation, Global warming, Green house gases, Methane emission, Pollution.

India possesses the largest (464 million) population of livestock in the world which are providing livelihood securities to 100 million households distributed in around 6 lakh villages. As per 17th Livestock Census (2003), India had 187.4 million cattle, 96.6 million buffaloes, 61.8 million sheep, 120.1 million goats, 14.1 million pigs and 2.7 million other animals. Thus India possesses about 15% of the world livestock population with only 2% of world geographical area (Singh et al 2011). This ever-exploding livestock population might affect the environment significantly through their continuous gaseous emission as well as waste material leading to the threat to the human life on earth.

According to FAO, livestock are responsible for 18% of greenhouse gases as measured in CO$_2$ equivalent, methane has 23 times more global warming potentials than CO$_2$ and is expected to cause 15-17% of global warming in the coming 50 years (Adam 2000).

Ruminants contribute to global warming by emitting CO$_2$ through respiration and methane through digestive process. Methane is second largest contributor to greenhouse effect after CO$_2$. 80% methane or even more is normally produced during digestive fermentation of feed stuffs in rumen by methanogens (methane producing bacteria). The methanogenic bacteria in rumen are Methanobrevibacter ruminantium, Methanobacterium mobile, Methanobacterium ruminantium, Methanobrevibacter smithii, Methanosarcina barkeri (Mudgal et al 1995).

In India major low quality roughage is used for maintenance of livestock, resulting in a higher level of methane production per unit of product. In general 8-12% of dietary energy is lost in the form of methane during enteric fermentation (Blaxter 1967).

During microbial digestion process in ruminants 97% volatile fatty acids (acetic, propionic, butyric acid) are produced and the rest 3% consists of methane, carbon dioxide and ammonia. Volatile fatty acids are absorbed into blood stream as source of energy. Where as methane is probably
no use to body and is a waste. The ruminant cannot utilize the methane because the rumen doesn’t contain methanotropic bacteria. About 8-9% of gross energy is lost as a result of methane production (Singh 2010). The methane production by Indian cattle and buffalo is about 80-96 gm/day/animal (Singh 1997). As per estimate of McAllister et al (1996), cattle produces 40 kg methane annually. Raghuvanshi and Singh (1991) also estimated similar methane emission. Possible due to this fact and taking into consideration the livestock population India is being held responsible in International forums for producing methane in high quality.

Out of the total methane emitted by the animal about 90 per cent of methane comes from fermentation in rumen and remaining 10 per cent comes from the hind gut (Torrent and Johnson 1994). The methane produced in rumen is released by belching and exhalation through mouth and nostrils. Depending upon the type, quality and quantity of feed, feeding level, physiological status, activity and health of animal methane production can go up to the level of 7% of total enteric fermentation products. Methane production per unit milk decreases with an increase in milk yield. It is interesting to note that the methane production of animal origin measures 240 gm per liter of milk in India as against 40 gm in western countries.

Fibrous diets of ruminants as generally practiced in India, results in higher methane production and lower their productivity. Studies in developed countries have indicated a positive correlation between increased productivity and methane reduction. EPA (1994) reported that increase in milk production from 3195kg to 7000 kg in USA from 1960 to 1990 reduced the methane emission from 24 to 17 g/kg milk as increase in milk yield reduced the maintenance energy requirement. Methane production per unit milk decreases with an increase in milk yield due to dilution of maintenance energy requirements. As in high milk producing animal most of the energy is utilized in milk production. Extra propionate formation for more milk yield will be responsible for lowering the methane formation (Singh et al 2010). However some reports indicate the reverse trends as reported by Kirchgessner et al (1995) and Leng (1991).

Large population of ruminants produces considerable quantity of methane gas and carbon di-oxide which are important in “Green House Effect”. These are detrimental to the environment. India ranks fifth in CO₂ and methane pollution and second in methane gas pollution. Out of the total methane produced 33% is attributed to animal origin (Mangurkar 2006). The share of methane emission by different species of live stock is Cattle – 41%; Buffaloes – 18%; Goat 25%; Sheep- 12% and Pigs – 3%.

The relative effectiveness of one kg methane in term of global warning potential is equal to 40 kg of CO₂. Hence India having largest livestock population is greatly related with its share in global warming. The Indian contribution of methane from all sources is around 12 % of the total world production (Singh et al 2010).

The study revealed that the total methane emission from the live stock production system in year 1992 was as follows in million tones (MT)

(A) Emission from enteric fermentation – 9.355 million Tones
(B) Emission from manure management – 0.202 million Tones.
(C) Emission from burning of dung cakes – 0.210 million Tones.

Total methane emission from livestock 9.767 million tones.

Global warming scenario (Global Climate Change). :- The United Nations Inter Government Panel on climate change (IPCC 2007) projects increase in global temperature ranging from 1.4 to 5.8 °C. by the year 2100. Due to rise in temperature the projected sea level rise is likely to be between 0.18-0.59 meters by the end of this century. IPCC also revealed that earth has become warmer over the last century by 0.6+/-.02 °C. Further it discovered that snow covers has decreased by 10 per cent since the late 1960 resulting in average global sea level rise in between 0.1 to 0.2 meter since 1900.

Citing IPCC data Upadyaya et al (2008) reported that due to global warming the mean temperature has increased between 0.3-0.6°C, the sea level has risen between 10-25 cm, CO₂ has increased by more than 20% and methane by 145% and their future predictions suggest warming by 2°C and sea level rise by 45-50 cm by 2100.

Mitigation of Methane Emissions

There is an urgent need to develop appropriate strategies for livestock development to mitigate the methane emission. Following are some of the ways to reduce methane emission from livestock.

Feeding of the live stock: The type of diet fed to the ruminant livestock can have major effect on methane production. Methane production by ruminant is actually a loss of feed energy from the diet and represents inefficient feed utilization. Depending on the type, quality and quantity of feed intake, feeding level can change the total enteric fermentation production which affects the methane emission also.

It is well documented that the poor quality of feed and fodder are the major reason for excess methane production, so dietary change will enhance the reduction of methane emission.

More concentrates feeding will increase the propionate production; the propionate is glycogenic in nature and utilizes the hydrogen. More the propionic acid formation more will be the milk quantity and lesser will be the methane production.

The higher concentrates also lower the rumen PH due to which some protozoa and methanogenes are eliminated which also results in low methane production.
But high concentrate feeding is associated with fertility problem.

Scientifically it is revealed that by 25% increase in carbohydrate level in diet will lower methane production by 20%. In vitro methane production on ration of green fodder of berseem, oat and maize with wheat or paddy straw resulted in 20-30% reduction in methane production. (Das and Singh 1999, Singh and Mohini 1999). To reduce methane gas emission supplementation of ruminant diet with molasses urea block lick, fiber pelletisation, processing of straw. Willium et al (1963), Tyagi and Singhal (1999) found that any other receptor of hydrogen except of carbon dioxide, like unsaturated fatty acids, oils and fats rich in fatty acids, if introduced in diet of ruminant can reduce the methane production. However there is one more aspect of dietary supplement of fatty acids/oils/fats in ruminants that their dietary excess may reduce the fiber digestion and microbial protein synthesis in the rumen.

Mike Abartone a scientist of Institute of Grassland and Environment Research revealed that by increasing feeding of fodder crops having more carbohydrates and leguminous fodder will reduce the methane pollution. Because the rumen micro-organism can degrade these easily. He also predicted that the methane emission depends on digestible quality of feeds and fodder. More digestible fodder consumption reduces the enteric methane emission. According to him a cow produces 100-200 liter of methane daily which can be reduced by supplying them good quality fodder. Recent report also suggest that feeding of leguminous fodder or some tropical fruits in diet (Hess et al 2001) reduce methane production by 20%.

The mixed farming system is an ideal choice to sustain the land and livestock resources.

Genetic improvement for milk production: More the milk production, lower will be the methane emission. In the high yielding animals the major diet energy is utilized for milk production. Where as in low yielding animals most of the diet energy is consumed for the body maintenance and thus resulting in more methane production.

The breeding strategies can play a significant role in improving the efficiency of the live stock. Crossbreeding between exotic and indigenous breed is not the universal solution. Upgrading of the local low producing stock with improved local breed may be advantageous in under developed area.

There is no control on the number and breeding of livestock so uncontrolled breeding should be stopped.

Propogation of unwanted degraded scrub animals should be prevented by sterilization of male and female's castration and use of biotechnological products like "Tulsar" are effective tool for sterilization of males.

New reproductive techniques such as artificial insemination, embryo transfer and conception, in vitro fertilization using ovum pick up techniques, oestrus synchronization, induced estrous and ovulation are some of the important methodologies being used for faster genetically development in production and reproduction traits in dairy cows. It is necessary to develop alternative strategies for rehabilitation of stray and unproductive animals.

Biotechnology: Use of biotechnology in live stock increase the milk yield and at the same time emission of GHG are reduced was observed by Neumeier and Mitloehrer (2013) during their study on effect of biotechnology in live stock on environment and milk yield, it is due to efficient use of animal, agricultural production and improvement in management of manure.(sourse Agroone a daily news paper related with agriculture)

Defaunation: Removal of protozoa from rumen is known as defaunation. Researchers are trying to alter the cattle and other dairy animals digestion, either by removing the micro-organism that produce methane from their rumen or by creating micro organisms that can produce metabolic end products other than methane. Defaunation improve the growth, food conversion efficiency, weight gain and performance of the animal (Coleman 1980, Chaudhary et al 1988, Bird 1989, Chaudhary and Mudgal (1989). Defaunation decreases the methanogenesis as most of the methanogenes are attached to protozoa.

Pal et al (1994) revealed that defaunation reduce methane production by 20-50% and improve the feed utilization efficiency.

<table>
<thead>
<tr>
<th>Method</th>
<th>Extent of reduction %</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Increase in concentrate mixture</td>
<td>20-32</td>
<td>Singh 1998</td>
</tr>
<tr>
<td>Supplementation of deficient nutrients</td>
<td>8-23</td>
<td>Singh 1998</td>
</tr>
<tr>
<td>Supplementation of UMM block</td>
<td>10-11</td>
<td>Singh 1999</td>
</tr>
<tr>
<td>Supplementation of green fodder</td>
<td>11-27</td>
<td>Singh and Mohini 1999</td>
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<tr>
<td>a) Maintenance ration</td>
<td>14-23</td>
<td>Singh 1999</td>
</tr>
<tr>
<td>b) Medium production ration</td>
<td>23-32</td>
<td></td>
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<tr>
<td>c) High production ration</td>
<td>14-25</td>
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**Acetogens**: They are rumen microbes that convert CO\(_2\) and H\(_2\) to acetate. In vitro study showed that supplementation of acetogens in rumen fluid decreases the methane production (Lopez et al 1999). These acetogens microbes are present in the rumen but in very few number and attempts to increase the acetogens have not successful but methane production can be lowered by using acetogens as a daily feed additive.

**Probiotics**: It refers to micro-organisms which when fed to animal has positive impact on host by improving gastrointestinal tract microbial balance. Commonly used cultures are *Aspergillus oryzae*, *Saccharomyces cerevisiae*, *Lactobacillus species*, *B. animalis* and *Streptococcus* species. They helped in improving the digestibility and over all performance. It was found that supplementation of *Aspergillus oryzae* reduces methane emission by lowering the protozoan population (Frumholtz et al 1989). Similarly *Saccharomyces cerevisiae* reduce methane emission by 10% (Mutsvangwa et al 1992). *Brevibacillus parabrevis* is reported to have the ability to convert methane into CO\(_2\) (Singh 2010).

**Herbs**: Garlic and cinnaman (component of clove bud) shows promising results in maintaining the healthy rumen (Kamel and Greathead 2007, Calsamglia et al 2007). Supplimentation of garlic and fennel, clove and garlic extract in ethanol and methanol reduces the methanogenesis in the rumen (Patra et al 2006).

**Biogas plants**: Cow dung gas contains 55-65 percent methane, 30-35 per cent carbondioxide and some hydrogen, nitrogen etc (Mishra and Mandal 2010). The dung can be used as source of energy by production of methane gas through biogas plant and remaining slurry can be used as organic manure for the farm.

The healthy value of Biogas methane is about 600 B.T.U. per cubic foot where as natural gas consists of around 80% methane, yielding about 1000 B.T.U. value. About one cubic foot of gas may be generated from one pound of cow manure which is sufficient to cook a days meal for a family of 5-6 people. About 1.7 cubic meter of biogas is equivalent to one liter of gasoline.

The dung slurry and urine can pollute the neighbouring water and environment. Stagnant pools are breeding and multiplication sources of flies and mosquitoes. Due attention is needed in compost management. Biogas formation utilize the dung as well as eliminate the multiplication of flies and insects.

Scientist from Hoenhem university Scyugart Germany had developed a herbal tablet on feeding of which reduces the enteric methane emission.

Disposal of animal carcass which is not satisfactory. Throwing dead bodies in open create a pollution as well as danger to the health of surroundings. It is basic need to find appropriate and cheaper method for utilization of dead bodies.

**Extension work**: Majority of the farmers are illiterate and they assume livestock farming as secondary business related to agriculture. They are not aware of methane emission, its disadvantages so it is necessary to educate them about environmental pollution through livestock management. They do not bother about genetic makeup, pedigree, breeding animal with high yielding bull, balance feeding etc. So it is need to train them about good management practices which indirectly affect the methane emission.

**REFERENCES**


