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Interaction and Coupling in the Emission of Greenhouse Gases from Animal Husbandry

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ABSTRACT:
Agriculture contributes significantly to the anthropogenic emissions of non-CO_2 greenhouse gases methane and Nitrous oxide. During this paper, a review is presented of the agriculture related sources of methane and Nitrous oxide , and of the most strategies for mitigation. The rumen is that the most vital source of methane production, especially in cattle husbandry. Less, but still substantial, amounts of methane are produced from cattle manures. In pig and poultry husbandry, most methane originates from manures. The most sources of Nitrous oxide are nitrogen fertilisers, land applied animal manure, and urine deposited by grazing animals. Best mitigation strategies for methane comprise a source approach, i.e. changing animals' diets towards greater efficiencies. Methane emissions, however, also can be effectively reduced by optimal use of the gas produced from manures, e.g. for energy production. Frequent and complete manure removal from animal housing, combined with on-farm biogas production is an example of an integrated on-farm solution. Reduced fertiliser nitrogen input, optimal fertiliser form, adding nitrification inhibitors, land drainage management, and reduced land compaction by restricted grazing are the simplest ways to mitigate Nitrous oxide emissions from farm land, whereas, management of bedding and solid manure reduce Nitrous oxide emissions from housing and storage. Aside from for methane, mitigation measures for Nitrous oxide interact with other important environmental issues, like reduction of nitrate leaching and ammonia emission. Mitigation strategies for reduction of the greenhouse gases should also minimize pollution swapping.
KEYWORDS: *Greenhouse gases, farming , Methane, emissions, nitrogen.*

I. INTRODUCTION

Global atmospheric concentrations of the foremost important greenhouse gases CO_2 (CO_2), methane (CH_4) and Nitrous oxide (N_2O) have increased significantly within the last 150 years. Stabilisation at today's levels and even reduced concentrations, necessary to scale back global climate change and corresponding effects, would require significant reductions in emissions of these gases (IPCC, 2001). These reductions are to be caused through adoption of mitigation measures from all sectors, e.g. industry, agriculture, energy and households. Agriculture contributes significantly to total greenhouse emission (GHG) emissions.

II. SOURCES AND PROCESSING

Methane and N_2O originate from different cycles. Methane is typically produced following the degradation of carbon (C) components during digestion of feed and manure, whereas, N_2O is said to the nitrogen (N) cycle with chemical fertilisers and manures because the most vital sources.

III. METHANE GAS

The rumen is that the most vital site of CH_4 production in ruminants (breath), whereas, in monogastric animals, like pigs, CH_4 is especially produced within the intestine (flatus). Animal manures, stored indoors in sub-floor pits or outdoors, also are relevant CH4 sources, since conditions usually favormethanogenesis in both slurry and solid manure heaps (Husted, 1994). Monteny et al. (2001) found the subsequent data for CH_4 produced from enteric fermentation and from manure, respectively, for various animal species (Table 1).

IV. ENTERIC FERMENTATION

The rate of CH_4 produced from enteric fermentation in dairy cows depends greatly on the extent of feed intake, the number of energy consumed (see IPCC, 1997), and feed composition. The three most vital factors are: (1) rate of organic matter (OM) fermentation; (2) sort of volatile fatty acids (VFA) produced, which strongly determines the surplus of hydrogen [H] produced within the alimentary canal and therefore the need for CH_4 production as a sink of excess hydrogen, and (3) efficiency of microbial biosynthesis.

V. FACTORS

The rate of OM fermentation is strongly influenced by level of feed intake and therefore the degradation characteristics of the carbohydrate fraction. for instance , Mills et al. (2001) demonstrated, during a theoretical study, that CH_4 production was reduced from 6.6 to 6.0% of the gross energy (GE) consumption by dairy cows when the dry matter intake of a 1:1-ratio of grass silage and concentrate diet was increased from 10 to 24 kg per day. Although CH4 production increases almost linearly with a better feed intake, the fraction of consumed GE lost as CH_4 reduces. This effect is partly a consequence of a discount in lower rumen digestibility with increased feed intake (factor 1), and partly a consequence of shifts within the rumen fermentation pattern and therefore the sort of VFA produced (factor 2).

Bannink et al. (2000), recently updated coefficients for the assembly of VFA from differing types of substrate fermented within the rumen of specifically lactating cows.

Current feed evaluation systems assume a rather constant figure for the efficiency of microbial synthesis (e.g. 150 g of protein per kg of OM fermented; Dutch protein evaluation system).

VI. ANIMAL MANURE

Fermentation of manure (digestion), both solid and liquid, is an anaerobic process (absence of oxygen). It's some similarities with enteric fermentation, and is described intimately , e.g. by Burton (1997) and Møller (2001). In brief, the fermentation process runs in two steps:

(a) Fast growth of acidogenic bacteria, active during a wide temperature range (3–70 8C) with an optimum at 30 8C. Intensive mixing of substrate and bacteria producing organic acids, [H], and CO_2.

(b) Specific methanogenic bacteria (psychrophilic, 40 8C) produce CH4 from organic acids.

Methane production from animal manure (also referred to as biogas) increases with temperature, and with increased biodegradability of the manure (or the mixture of manure and by-products; see e.g. Wulf et al., 2005).

VII. NITROUS OXIDE

The main sources of N_2O are nitrogen fertiliser and animal manure applications to land, and urine deposition by grazing animals (Brown et al., 2001), although it also could also be released in deep litter systems and from solid manure heaps (Chadwick et al., 1999). Even silage clamps could also be a source of N_2O. Whereas, CH_4 is usually produced from animal manures, N_2O production only takes place under specific conditions since it results from combined aerobic and anaerobic processes:

(a) nitrification: transformation of ammonium to nitrate (aerobic);

(b) denitrification: formation of nitrogen gas from nitrate reduction (anaerobic).

As a consequence, N_2O emission is influenced by the environmental factors oxygen status, temperature, moisture content and antecedent soil conditions, which control enzyme production. Normally, conditions in manure are strictly anaerobic, and processes (a) and (b) won't occur. However, when forced and controlled aeration of liquid manure ('aerobic treatment') or solid manure ('composting') is employed to realize removal of OM and nitrogen, and water (drying), respectively, denitrification occurs after aeration. Besides these samples of active nitrification/ dentrification, the processes (a) and (b) also happen during a situation of passive aeration, e.g. in organic housing systems and systems with enhanced animal welfare where straw or litter could also be introduced. The mixture of manure and straw/litter, combined with (partial) compaction of the bedding creates conditions that favor passive aeration, leading to uncontrolled nitrification and denitrification (Groenestein and Van Faassen, 1996). Although ammonia emissions from these sorts of housing systems are usually reduced, there's a big trade off to N_2O (and CH_4), leading to a net higher N-emission than observed from traditional, liquid manure based, housing systems.

VIII. MITIGATION OPTIONS

8.1. Methane

Methane emission per unit of animal material are going to be reduced by any process that increases the ratio of livestock 'production' to 'maintenance'. Thus faster growth, higher milk yields and shorter dry periods in lactating cows will lower CH_4 emissions. Likewise, a rise within the average longevity of dairy cows (i.e. a greater number of lactations per lifetime) relative to the amount from birth to first calving (usually 3 years) will reduce CH4 loss per unit of milk yield. Additionally, measures concerning technology (e.g. aerobic digestion) and management based solutions could also be implemented (Harrison et al., 2003). However, only mitigations that involve a discount within the number of animals would currently register as a discount within the IPCC inventory (IPCC, 1997) because this is often supported a typical emission factor. Other sorts of mitigation, for instance those supported manipulation of the diet, could produce 'real' reductions in CH_4 production, but presently these would go unrecorded within the inventory, unless they indirectly led to a discount in livestock numbers.

8.1.1. Dietary measures

It is widely known that alterations within the diet strongly affect rumen functioning and therefore the performance of ruminants (e.g. roughage: concentrate ratio, or the fibre, starch, sugars and protein content of the feed). Similarly, dietary composition may strongly affect the availability and subsequent fermentation of substrate within the intestine of pigs also as ruminants (quantity of and sort of starch, fibre and protein inflow to large intestine). especially, the fermentative capacity of the massive intestine of pigs is excessive, whereas, it's considered minor in ruminants as compared thereto of the rumen. Changes in feeding strategy or farm management may have an outsized impact on GHG production by livestock.

8.2. Nitrous oxide

Options to scale back N_2O emissions from specific sources are identified and tested to varied degrees. during a recent review of greenhouse emission emissions from agriculture within the UK, Harrison et al. (2003) concluded that the foremost effective potential specific options are: (1) choice of fertiliser form, (2) nitrification inhibitors, (3) land drainage management, (4) storage of solid manure, (5) N_2O:N_2 ratio, and (6) housing systems and management.

8.2.1. Choice of fertiliser form

Fertiliser type is assumed to influence N_2O emissions, with nitrate-based fertilisers leading to greater emission factors than ammonium-based fertilisers. for instance , a review conducted by Eichner (1990) suggested that the typical emission factor for nitrate was 0.44% whilst that for urea was 0.11% of the N applied. During a newer experimental study, Dobbie and Smith (2003a) compared N_2O emissions from various fertiliser types with and without various inhibitors (nitrification and urease).

8.2.2. Addition of a nitrification inhibitor

Nitrification inhibitors (NIs) are often added to urea or ammonium compounds. within the study by Dobbie and Smith (2003a) the utilization of a NI with urea fertilisers reduced N_2O emissions compared to urea alone. Nitrapyrin, dicyandiamide (DCD) and 3 ,4-dimethylpyrazole phosphate (DMPP) have well-demonstrated effectiveness for lowering N_2O emissions from fertiliser and animal slurries (Pain et al., 1994). Dittert et al. (2001) demonstrated a win–win scenario using DMPP additions to dairy slurry.

8.2.3. Land drainage

There is a well documented relationship between N_2O emissions and water filled pore space whereby water filled pore space of quite 70% leads to significant N_2O emissions (Maag, 1990; Dobbie and Smith, 2003b). Therefore, improvement of soil physical conditions to scale back soil wetness, especially in grassland systems, may significantly reduce N_2O emissions. for instance , neglect of land drainage within the UK since the cessation of subsidies means soil aeration status has been gradually deteriorating. Improving drainage would be particularly beneficial on grazed grassland. Soil compaction by traffic, tillage and grazing livestock can increase the anaerobicity of the soil and enhance conditions for denitrification. it's thought that treading by cattle could increase emissions of N_2O by an element of two (Oenema et al., 1997). Clark et al. (2001) suggested that by avoiding compaction, the entire national N2O emission (for 1998) might be reduced by 3%.

8.2.4. Solid manure stores

Specific N_2O mitigation options from solid manure heaps include the addition of high C substrate. Also, compaction of solid manure heaps to scale back oxygen entering the heap and maintaining anaerobic conditions has had mixed success in reducing N_2O emissions (Chadwick, unpublished). In contrast, one would expect CH_4 emissions to be increased following compaction of heaps, i.e. a case of swapping one sort of pollutant for an additional.

8.2.5. N_2O:N_2 ratio

Nitrous oxide is one among the products of nitrification (Bremner and Blackmer, 1978), whilst both nitrogen gas (N_2) and N_2O are products of denitrification (Firestone and Davidson, 1989). Increased knowledge of the factors controlling the N2O:N2 ratio might be wont to inform management practices which will cause a greater proportional flux of N2 (compared to N2O). Carbon quality is understood to influence the ratio of N_2O:N_2 (Paul et al., 1993).

Hence, an improved understanding of the influence of anaerobic digestion and storage of slurry on C quality at the time of manure application may end in improved management practices to scale back N_2O emissions. Amon et al. (2002) showed that the N_2O emissions from slurry applications to grassland were reduced when slurry had been stored for six months or had skilled an anaerobic digester before spreading as compared to fresh slurry. The inference being that in storage and anaerobic digestion readily available C (that might be wont to fuel denitrification) is incorporated into microbial biomass or lost as CO_2 or CH_4, hence there's less available C within the slurry to fuel dentrification when the slurry is applied to land. Indeed anaerobic digestion is potentially a ‘win–win’ management of animal slurry, since CH_4 emitted during storage (as biogas) is employed to supply heat and electricity, whilst N_2O emissions following the spreading of the digested slurry also are reduced (see for instance , Clemens et al., 2005).

8.2.6. Housing and management system

The choice of manure management and housing system will influence greenhouse emission emissions, particularly N_2O. Changes of practice, e.g. for reasons of animal welfare, may increase straw use and hence the assembly of solid farm yard manure (FYM). Animal housing and manure stores of straw-based systems (deep litter) will end in greater N_2O emissions than the more anaerobic slurry-based systems (Thorman et al., 2003; Groenestein and Van Faassen, 1996).

So, a management change from straw- to slurry-based systems may end in lower N_2O emissions. Some dairy and beef farmers are extending the grazing season to scale back feed costs and labour. This may generally not affect CH_4 emissions, but it's going to increase the danger of N_2O emissions and nitrate leaching. Minimising the grazing period is probably going to scale back N_2O emissions, since the more uniform return of excreta via slurry spreading leads to lower emissions than from urine deposited by grazing animals (Oenema et al., this issue).

IX. CONCLUSIONS

Agriculture generally, and livestock production especially , contribute to heating through emissions of the non-CO_2GHGes CH_4 and N_2O. Most CH_4 is emitted from ruminants (animal + manure), whereas, N_2O is especially emitted from fertilized land. Methane mitigation options from ruminants specialise in increasing production per animal, modifying diet, decreasing numbers of methanogens and methanogen activity and by reducing livestock numbers. Manure related CH_4 are often reduced by minimizing uncontrolled storage (indoors). Controlled storage offers possibilities for utilization of CH_4 produced (biogas). Nitrous oxide mitigation options include better N use (from fertilisers and manures), land drainage, use of nitrification inhibitors. Mitigation of N_2O from solid manure heaps might be achieved through the utilization of high C additives and compaction. Anaerobic digestion of slurries are often wont to (a) directly reduce CH_4 emissions through biogas generation (heat and energy production) and (b) indirectly reduce N_2O emissions when slurries are applied to land by decreasing the readily available C content. It's essential that GHG mitigation options take other policies under consideration, e.g. the need to scale back NO_3 leaching and NH_3 volatilisation. It should be noted that, a discount within the amount of fertiliser N used through more efficient use, e.g. by timing applications and rates to crop requirements, also as an integrated approach to the utilization of animal manures with fertilisers to provide N for crop growth should reduce the danger of excess mineral N remaining within the soil in danger of loss as N_2O. Such improvement in fertiliser and manure management would play a crucial role in reducing not only N_2O emissions but also other losses of N, e.g. as ammonia and nitrate.

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