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CÂMPUS DE JABOTICABAL

GREENHOUSE GAS EMISSIONS AND N_2O MITIGATION IN BEEF CATTLE PRODUCTION ON TROPICAL PASTURE

Abmael da Silva Cardoso

Engenheiro Agrônomo

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Orientadora: Profa. Dra. Ana Cláudia Ruggieri

Tese apresentada à Faculdade de Ciências Agrárias e Veterinárias – UNESP, Câmpus de Jaboticabal, como parte das exigências para a obtenção do título de Doutor em Zootecnia.

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TÍTULO: GREENHOUSE GAS EMISSIONS AND N_2O MITIGATION IN BEEF CATTLE PRODUCTION ON TROPICAL PASTURE

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Jaboticabal, 03 de fevereiro de 2016.

DADOS CURRICULARES DO AUTOR

ABMAEL DA SILVA CARDOSO was born in Ceres, Goiás, Brazil in 19 of July of 1987. In the early years of your life he was influenced by the Agronomist and Pioneer Bernardo Sayão that founded Ceres. To 14 years started a high school in Agriculture in the Federal Institute of Science and Technology Goiano campus Ceres where still with 14 years old carried out his first experiment evaluating the allelopathic effect of *Cynodon nlemfuensis* Vanderyst on the weeds under supervision of Dr. Luís Sérgio Rodrigues Vale. In the first years of high school was named by the Brazilian Minister of Education the student member (2002-2004) in the Director Council of the EAF-Ceres. In 2003 was president of students association of EAF-Ceres. He was the orator of the 2004 high school class of IFGoano (Campus Ceres). With 17 years started Agronomy in the Federal Rural University of Rio de Janeiro (UFRRJ) where received the title of Agronomist in 2009. During his undergraduate program he works in the laboratory of Soil Fertility, Soil Physics and Global Information System in the university. Also participate of the Federation of Agronomy Students of Brazil (FEAB) from 2005 to 2008 representing the Agronomy students of UFRRJ. In 2006 did the exam to the Embrapa Agrobiology (Seropédica-Rio de Janeiro) initiation in science obtain the better grade. In 2007 started the traineeship in science in the Nutrient Cycling group of Embrapa Agrobiology under supervision of Dr. Bruno José Rodrigues Alves, Dr. Segundo Urquiaga and Dr. Robert Michael Boddey. At this period Abmael started inspiriting himself follow the example of Dr. Johanna Döbereiner (Scientist, Agronomist and Pioneer). In 2008 was director in the Agronomic Studies Center (Students associations) and represented the students in departments and course council. In 2012 obtained the title of Master Science (Soil Science) at UFRRJ. During his master worked with methodology of soil greenhouse gas evaluations and life cycle inventory of greenhouse gas emissions in different beef cattle production systems based on IPCC (2006) methodology working in the Nutrient Cycling group of Embrapa Agrobiology. In 2012 started the doctorate program in Animal Science in the São Paulo State University “Júlio de Mesquita Filho” working under supervision of Dr. Ana Claudia Ruggieri in the Group of Grassland and Forage Science doing evaluations of options to mitigate nitrous oxide from beef cattle production and quantified greenhouse gas emissions direct and indirect from grassland soil, urea fertilizer and beef cattle excretes. During his doctorate spent one year in the Dr. Johan Six Group at Federal Institute of Technology of Zurich (Zurich-Switzerland) learning about isotopic techniques (^{15}N) and pyrolyzed organic matter (Biochar). In February of 2016 concluded the doctorate program in Animal Science obtained the title of Doutor em Zootecnia.

Epigraph

Zulu umuntu ngumuntu ngabantu.

(Uma pessoa é uma pessoa através de outras pessoas)

Ubuntu. In honor of our ancestors.

"I am who I am, because we are all us". Collaboration should be your essence, not the competition.

"No one has ever seen God; but if we love another, God lives in us and his love is made complete in us. This is how we know that we live in him and He in us: He has given us of his Spirit."
Apostle John

I dedicate

To my family, pioneers, that moved to Ceres-Goiás:

João Benjamim Gomes and his wife Fermina Maria de Araújo from Cumari-Goiás;

Sebastião Inácio da Silva and his wife Idaria Minervina de Jesus from Araguari-Minas Gerais;

Antônio Venâncio Martins and his wife Maria do Carmo Ramos from Formiga-Minas Gerais;

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To the Jesus. He has given us this command: Anyone who loves God must also love their brother and sister. John I 4:21.

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SUMMARY

EMISSÃO DE GASES DE EFEITO ESTUFA E MITIGAÇÃO DE N_2O NA PRODUÇÃO DE BOVINOS DE CORTE EM PASTAGENS TROPICAIS

RESUMO: Metano (CH_4) e óxido nitroso (N_2O) são dois dos mais importantes gases de efeito estufa emitidos pela pecuária. Eles são produzidos pelas excretas dos animais e fertilizantes. No Brasil, a quantidade emitida destes gases e opções para mitigação foram pouco exploradas. Uma sequência de 4 experimentos foram realizados em campo (em duas estações chuvosas e duas secas, 106 dias de duração cada) com o objetivo de quantificar as emissões de N_2O e CH_4, volatilização de NH_3 e o fator de emissão (FE) quando aplicadas fezes, urina, fezes + urina e fertilizante ureia em Latossolo Vermelho cultivado com capim-marandu. Investigou-se o efeito da umidade do solo e compactação, composição da urina, volume urinário, e adição de fezes sobre as emissões de N_2O em um Latossolo recebendo urina manipulada em condições controladas, bem como nas emissões de CH_4. Como opção para mitigar as emissões de gases de efeito estufa (GEE) foram estudadas as variáveis como as alturas de pastejo que afetam a magnitude das emissões de GEE; a influência estacional na produção e consumo dos GEE; quais são as variáveis chaves associadas com as emissões de GEE em pastagens de capim-marandu. Adicionalmente, investigou se o efeito dietético dos níveis do sal mineral na concentração de N na urina, o volume urinário, a proporção dos compostos nitrogenados na urina e a concentração de N nas fezes em condições de campo. Os FEs de N_2O quantificados diferiram de acordo com a excreta e estação do ano. O FEs foram 2,34%, 4.26% e 3,95% na estação chuvosa e 3.00%, 1.35% e 1.59% na estação seca, respectivamente, para fezes, urina e fezes + urina. O FE do fertilizante ureia foi 0,37%. As emissões médias do CH_4 acumuladas foram 99,72, 7,82 e 28,64 (mg C-CH_4 m^2) para fezes, urina e fezes + urina nesta sequência. Quando manipuladas as condições do solo como umidade, compactação e adição de fezes as emissões de N_2O foram influenciadas sendo maiores nos tratamentos com adição de fezes. Ao se variar a concentração do N-urinário aplicado (em igual volume de urina) afetou a produção de N_2O diminuindo as emissões da maior para a menor concentração de N aplicada e não foi observado efeito ao se variar o volume de urina aplicado (contendo igual concentração de N-urinário). A concentração de

KCl adicionada na urina afetou as emissões de N_2O de forma curvilínea enquanto o tipo de composto nitrogenado não. Ao se estudar as emissões de CH_4 estas responderam aos fatores do solo como umidade, compactação e adição de fezes e não foram afetadas pela variação da concentração de N-urinário e volumes de urina. A fonte de nitrogênio aplicada não afetou a produção/oxidação de CH_4. A altura do pasto, estação e ano afetaram as emissões de N_2O e CO_2 e a estação as de CH_4. As maiores emissões ocorreram no verão e as menores no inverno. A altura do pasto apresentou efeito linear negativo nas emissões de N_2O acumuladas anual e linear positivo nas emissões de CO_2. O efeito dietético dos níveis de sal mineral influenciaram a concentração de N-urinário, volume de urina, N-ureia, N-alantoína e N-ácido hipurico. A concentração de N-urinário apresentou efeito negativo linear, o volume de urina, N-ureia, N-alantoína e N-ácido hipúrico positivo linear. Enquanto que a excreção total de N excretado via urina, N-creatinina e concentração de N nas fezes não foram afetadas pelos níveis de sal mineral na dieta. As emissões de CH_4, N_2O e NH_3 diferiram dos FEs *defaults* preconizados pelo IPCC. A umidade e a compactação do solo podem ser os principais fatores que regulam as emissões de N_2O e CH_4 e depende da variação sazonal da precipitação pluviométrica.

Palavras-chave: Emissão de CH_4 do solo, mudanças climáticas, quantificação de N_2O, volatilização de NH_3

GREENHOUSE GASES EMISSIONS AND N_2O MITIGATION OF BEEF CATTLE PRODUCTION ON TROPICAL PASTURES

ABSTRACT: CH_4 and N_2O are two of the most important greenhouse gas emitted by livestock. They are produced from animal excretes and the fertilizer. In Brazil the amount and options to mitigate these gases are little explored. We carried out a sequence of 4 field-trials (two rainy and two dry season, 106 days each) aimed to quantify the N_2O and CH_4 emissions, NH_3 volatilization and emission factor (EF) after application of dung, urine, dung + urine and urea fertilizer on a Ferralsol of a marandu palisade-grass pastureland of Brazil. We aimed to investigate the effects of soil moisture, soil compaction, urine composition, urine volume, and dung addition on N_2O emission from a urine-treated tropical Ferralsol under controlled conditions as well on CH_4 emission. As option to mitigate greenhouse gas (GHG) emissions we studied how grazing heights affect the magnitude of GHG emissions; how season influence GHG production and consumption; what are the key driving variables associated with GHG emissions. Additionally, we investigated the effect of dietary mineral salt levels on urine-N concentration, urine volume, the proportion of N compounds in the urine and faeces-N concentration under field conditions. The emissions factor (EF) calculated differed according excretes and season. The EFs were 2.34%, 4.26% and 3.95% in the rainy season and 3.00%, 1.35% and 1.59% in the dry season, respectively, for the dung patches, urine patches and dung + urine. The N_2O EF from urea was 0.37%. The averages of CH_4 accumulated emissions were 99.72, 7.82 and 28.64 (mg CH_4-C m^2) for dung, urine and dung + urine in this sequence. The manipulated soil conditions moisture content, compaction, and dung addition affected N_2O emissions when varying quantities of urine-N were applied (in equal urine volumes) being higher when added dung and did not affect when varying urine volumes were applied (containing equal quantities of urine-N). The urine-N concentration influenced N_2O emissions decreasing from the lower concentration to the higher and the chemical form of urine-N did not. The concentration of KCl added to the urine influenced N_2O emissions presenting a curvilinear curve. When the CH_4 emissions were influenced by soil factors moisture content, compaction and dung addition and did not responded to the variation in the urine-N concentration and volume. The source of N did not influence the CH_4 emissions/oxidation. Pasture height, season and year affect N_2O and CO_2 emissions and the season CH_4 releases. The greater emissions occurred in the summer and the lower in the winter. Pasture height had negative linear effect on annual cumulative N_2O emissions and positive linear effect on annual cumulative CO_2 emissions. Dietary effects of mineral salt level influenced the N concentration in the urine, urine volume, urea-N, allantoin-N and hyppuric acid. While the total N excreted daily via urine, creatinine-N and N concentration in feces were not affected by mineral salt level in the diet. The emissions of CH_4, N_2O and NH_3 differs that default EFs preconized by the IPCC. Soil moisture and compaction appear to be the main factors regulating N_2O and CH_4 emissions and depends of the rainfall seasonality.

Key-words: N_2O quantification, NH_3 production, CH_4 emissions from soil, climate change.

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List of Abbreviations

ADF	Acid Detergent Fiber
ANOVA	Analysis of Variance
C	Carbon
C	Cubic
CFCs	Fluorinated gases
CH_4	Methane
CH_4	Metano
CO_2	Dióxido de Carbono
CO_2	Carbon Dioxide
COP	Conference of the parties
CP	crude protein
DAA	Days After Application
DM	Dry matter
ECD	Electron Capture Detector
EF	Emissions Factor
EF1	IPCC emissions factor for N_2O emitted from N fertilizer application to the soil
$EF3_{PRP}$	IPCC emissions factor for N_2O emitted from urine and dung deposited on pasture
FCAV	Faculdade de Ciências Agrárias e Veterinárias
FE	Fator de Emissão
FID	Flame Ingestion Detector
GEE	Gases de Efeito Estufa
GHG	Greenhouse gas
He	Helium
H_2SO_4	Sulfuric Acid
IPCC	Painel Intergovernamental para Mudanças Climáticas
IPCC	Intergovernmental Panel on Climate Change
KCl	Potassium Chloride
L	Linear
LW	Live Weight
N	Nitrogen
N_2	Gas Nitrogen
N_2O	Nitrous oxide
N_2O	Óxido nitroso
NaCl	Sodium Chloride
NAMAs	Nationally Appropriate Mitigation Actions
NCF	Nitrogen concentration in feces
NCU	Nitrogen concentration in urine
NDF	Neutral Detergent Fiber
NEU	Nitrogen excreted via urine

NH_3	Ammonia
NH_3	Amônia
NH_4^+	Ammonium
NH_4Cl	Ammonium chloride
NO	Nitric oxide
NO_3^-	Nitrate
NRC	National Research Council
O_2	Gas oxygen
O_3	Ozone
p	probability
Q	Quadratic
RPS	Rumen Protein Surplus
SEM	Standard error of means
SOM	Soil Organic Matter
TCD	Thermal Conductivity Detector
Unesp	Universidade Estadual Paulista "Júlio de Mesquita Filho"
UUN	Urinary Urea-N
UV	Urine Volume
%WFPS	% of Water Filled Pores Spaces

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CEUA – COMISSÃO DE ÉTICA NO USO DE ANIMAIS

CERTIFICADO

Certificamos que o Protocolo nº 004389/13 do trabalho de pesquisa intitulado **"Avaliação do sal em dietas de bovinos em pastagem com estratégia de mitigação de N_2O"**, sob a responsabilidade da Profª Drª Ana Cláudia Ruggieri, de acordo com os Princípios Éticos na Experimentação Animal, adotado pelo Colégio Brasileiro de Experimentação (COBEA) foi aprovado pela COMISSÃO DE ÉTICA NO USO DE ANIMAIS (CEUA), em reunião ordinária de 13 de março de 2013.

Jaboticabal, 15 de março de 2013.

Andrigo Barboza De Nardi

Prof. Dr. Andrigo Barboza De Nardi
Coordenador - CEUA

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CHAPTHER 1 - GENERAL CONSIDERATIONS

1. GLOBAL WARMING AND GREENHOUSES GASES

Atmosphere has important hole to the life in the Earth. In 1822 Joseph Fourier published the book “The Analytical Theory of Heat”, and suggested that the atmosphere played a critical role in warming the Earth’s surface. It was experimentally verified by John Tyndall in 1861, and quantified by Svant Arrhenius in 1896 (LACIS et al. 2010). Greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (CFCs) are capable of absorbing infrared radiation, thereby trapping and holding heat which causes the greenhouse effect (ROYAL SOCIETY, 2010).

In 1960 Charles Keeling showed that the level of CO_2 in the atmosphere was in fact increasing. He plotted year by year along with rise of the atmospheric CO_2 of Mauna Loa Observatory in Hawaii (KEELING, 1960) starting the “Kelling Curve”. In 1972 John Sawyer published the study “Man-made Carbon Dioxide and the Greenhouse Effect”. His publication influenced the policy maker and accurately predicted the rate of global warming between 1972 to 2000 (NICHOLLS, 2007). Ramanathan (1980) published an estimate of the contribution to global warming from CH_4, N_2O and O_3 produced by industry and by agricultural sources such as fertilizer. He calculated that these gases might contribute as much as 40% of total warming due to CO_2 and all other gases of anthropogenic origin. Then agriculture figured as a contributor to greenhouse gas emissions and global warming effect.

Due to the importance of climate change in 1988 the world meteorological association established the Intergovernmental Panel on Climate Change (IPCC). The IPCC is constitute by more than 2000 scientists and have the general main to assess scientific information relevant to human-induced climate change, the impacts of human-induced climate change (IPPC, 2006). In 1997 in the third conference of the parties (COP) resulted in the Kyoto Protocol which adopted GHG reduction obligation for the signatory countries. Brazil as signatory started to report GHG emissions in national inventory.

In the 2000’s were observed successive records on the atmospheric temperature measured in different point of the Earth. The importance of climatic change increase even more and in 2009 in the COP 15 countries like Brazil adopted Nationally Appropriate Mitigation Actions (NAMAs). Brazil assumed voluntary like reduction in deforestation, restoration of grassland, adoption of integrated crop-livestock system and biological N_2 fixation aimed to lead to an expected reduction of 36.1% to 38.9% regarding the projected emissions of Brazil by 2020 (Brazil, 2009).

November of 2015 was the world's warmest November in recorded weather history. The global average temperature in last November was warmer by 1.05 ºC than the overall average global temperature for the years 1880-2015 (NOAA, 2015). Finally, in the COP 21 almost 200 countries approved the adoption of the Paris Agreement "Recognizing that climate change represents an urgent and potentially irreversible threat to human societies and the planet and thus requires the widest possible cooperation by all countries, and their participation in an effective and appropriate international response, with a view to accelerating the reduction of global greenhouse gas emissions". (UNFCCC, 2015). Despite these consensuses many gaps in climatic change knowledge still persist.

2. CARBON DIOXIDE

John Tyndall in 1864 studied the ability of CO_2 absorb infrared radiation. He observed that CO_2 and CH_4 strongly block the radiation (TYNDALL, 1872). Arrhenius (1896) calculated that the surface temperature to be an increase in 5-6ºC doubling atmospheric CO_2 and because of the relatively low rate of CO_2 production in 1896, the warming effect would require thousands of years, and he projected it would be beneficial to humanity. However, atmospheric CO_2 reached 143% of the pre-industrial level in 2014. The globally averaged CO_2 mole fraction in 2014 was 397.7±0.1 ppm (WMO, 2015). Based on the average growth rate for the past decade the CO_2 will be achieving the double of the pre-industrial level in 2095.

The combustion of fossil fuels and cement production accounted 91% of CO_2 emissions in 2013 and the deforestation and other land-use change responded by 9%, according to (http://www.globalcarbonproject.org). In the beef cattle system the sources of CO_2 are from fuel consumption and agricultural inputs like fuels and electricity, fertilizer and lime, pesticides, irrigation, seed production; from tillage practice like farm machinery instrumentation (CARDOSO et al., 2016a).

The biomass of plants and soil organic matter (SOM) could be sink or source of CO_2. It is a sink when the land use change from crop to forest, for example, when the tree growing accumulates C and the SOM stocks increases due crop practices like no tillage and mixed systems. In the other side biomass burning and SOM oxidation release CO_2 to the atmosphere.

An important concern is about the capacity and contribution of agricultural soils and reforestation contributed reducing CO_2 emissions. Sauerbeck (2001) pointed that, even if most carefully preserved, both forests and soils, with the exception of unmanaged wetlands, have a finite capacity to sequester carbon, which gets saturated within less than 100 years. He attributed to this reason that many scientist disagree with the idea of reforestation and additional incorporation of carbon into agricultural soils would partially substitute for the commitment of reducing the CO_2 emissions from fossil fuels.

3. METHANE

Only after 86 years that Tyndall showed that the CH_4 block the radiation the presence of this gas in the atmosphere was found (MIGEOTTE, 1948). Globally averaged CH_4 reached 1833 ppb in 2014 and increased 254% since pre-industrial level. CH_4 contributes with approximately 17% to radioactive forcing (the rate of energy change per unit area of the globe as measured at the top of the atmosphere) and 60% of the emitted CH_4 into the atmospheres comes from anthropogenic source (e.g. ruminants, rice agriculture, fossil fuel exploitation, landfills and biomass burning) (WMO, 2015).

Methane is produced in the soil as one of the final compound of the complete mineralization of SOM in wetlands. The environmental factors that affect CH_4 emissions by soils are gas diffusion, microbial activities which depends of temperature, pH, Eh, substrate availability and methane-mono-oxygenase activity (Le MER and ROGER, 2001). The ability of micro-organisms to oxidize methane has been known since 1906, when Söhngen first isolated an organism capable of growing on methane as a carbon source and named it *Bacillus methanicus* (SÖHNGE, 1906). It was called methanotrophy. Methanotrophs are obligate aerobes and one possible reaction is $CH_4 + 2\ O_2 = CO_2 + 2\ H_2O$. The rate of CH_4 oxidation depends of the composition and biodiversity of CH_4-oxidizing consortia (MOHNATY et al. 2007), temperature (BÖRJESSON et al., 2004) and soil moisture have been suggested as a major controlling factor in numerous studies (e.g. ZEISS, 2006; JUGNIA et al. 2008; SPOKAS and BOGNER, 2011).

In the national greenhouse gas inventory CH_4 enteric and manure should be reported. In grassland soils the main source of CH_4 is the dung deposition. The IPPC guidelines (2006) preconizes a default emissions factor of 1 kg CH_4 head^{-1} year^{-1}. In Brazilian condition a few studies were published and at this time the average emissions are 0.31 kg CH_4 head^{-1} year^{-1} (Table 1).

Table 1 - CH_4 emissions factor (kg CH_4 head^{-1} year^{-1}) quantified for dung deposition in Brazilian conditions

Location	Season	Animal	Emissions	Reference
Ariquemes-RO	Spring	Heifer	0.60	Chiavegato (2010)
Piracicaba-SP	Winter	Steers	0.02	Mazzeto et al. (2014)
Piracicaba-SP	Summer	Steers	0.05	Mazzeto et al. (2014)
Ariquemes-RO	Winter	Steers	0.06	Mazzeto et al. (2014)
Ariquemes-RO	Summer	Steers	0.10	Mazzeto et al. (2014)
Seropédica-RJ	Autunm	Dairy	0.96	Cardoso et al. (2016b)
Jaboticabal-SP	Winter	Steers	0.18	This thesis
Jaboticabal-SP	Summer	Steers	0.79	This thesis
Jaboticabal-SP	Incubation	Steers	0.25	This thesis
Jaboticabal-SP	Incubation compacted soil	Steers	0.33	This thesis
Average			0.31	

4. NITROUS OXIDE

Adel (1947) showed the existence of N_2O in the atmosphere and speculated that soil air to be one source, perhaps the principal one, of the atmospheric nitrous oxide and Crutzen (1970) confirmed the influence of N_2O on the atmospheric ozone content. In 2014 N_2O concentration in the atmosphere reached 327 ppb and increase 121% since the pre-industrial level (270 ppb). The anthropogenic sources contributed with approximately 40% of N_2O emissions, including oceans, soils, biomass burning, fertilizer use and various industrial processes (WMO, 2015).

N_2O is produced in soil during the reactions of nitrification and denitrification. Nitrification, which requiries aerobic conditions, depends on NH_4^+ supply and is mediated by autotrophic bacteria, whereas denitrification is executed by anaerobic heterotrophic bacteria, which depend on the availability of labile organic C and NO_3^-. Firestone and Davidson conceived a model called "hole-in-the-pipe" (Figure 1), which synthetized the knowledge at that time about the microbiological and ecological factors influencing soil emissions of nitric oxide (NO) and N_2O. (DAVIDSON et al. 2000).

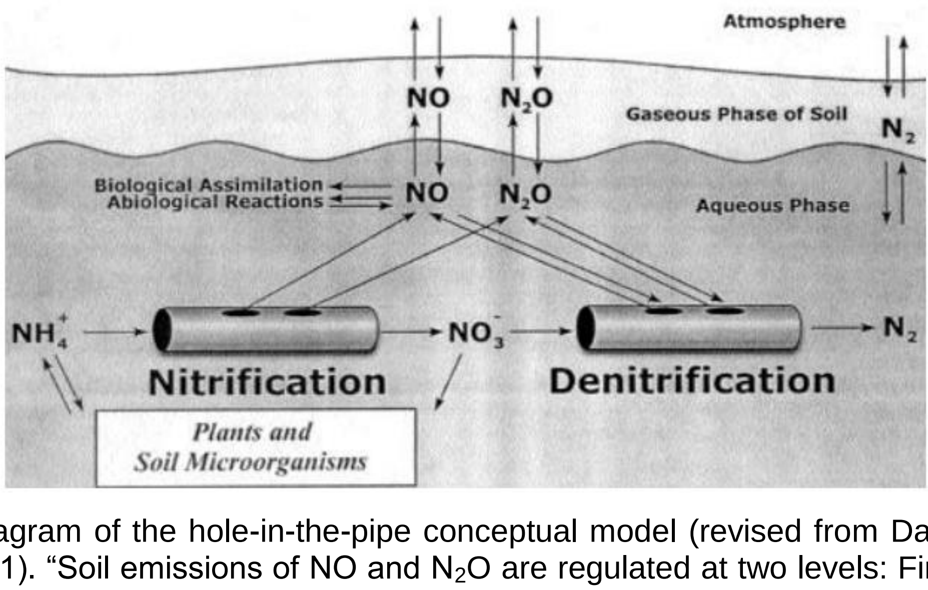

Figure 1. Diagram of the hole-in-the-pipe conceptual model (revised from Davidson 1991). "Soil emissions of NO and N_2O are regulated at two levels: First, the rate of nitrogen cycling through ecosystems, which is symbolized by the amount of nitrogen flowing through the pipes, affects total emissions of NO and N_2O; second, soil water content and perhaps other factors affect the ratio of N_2O:NO emissions, symbolized by the relative sizes of the holes through which nitric oxide and nitrous oxide leak"(Davidson et al., 2000).

There are two categories of factors that control N_2O emissions. Oenema and Sapek (2000) specified environmental factors and management factors. Soil issues such as inorganic-N, aeration, organic matter and soil moisture are the principal factors. Precipitation and temperature are the most important climate factors. In this group of factors Butterbach-Bahl et al. (2013) argued that soil moisture controls N_2O emissions because it regulates the oxygen availability to soil microbes. Management factors in grassland systems on N_2O emission are: nitrogen fertilizer, manure application and timing of application; the intensity of grazing, soil compaction and liming application (OENEMA and SPEK, 2000). Grazing is important factor because it determines how much dung and urine is deposited on grassland from the animals (NÚÑEZ et al., 2007).

Nitrous oxide emission factors (EF) are used to calculate excreta and fertilizer contributions for N_2O national inventory (IPCC, 2006). They are the ratio of N_2O-N emitted from a soil that was added an N input, minus the N_2O-N emitted from the soil that did not receive N, divided by the amount of N applied (BUCKTHOUGHT et al., 2015). Default emission factors are stipulate by the IPCC guidelines as 0.01 and 0.02 kg N_2O-N kg^{-1} input for EF_1 (N additions from mineral fertilizers) and EF_{3PRP} (excretal N inputs to grasslands), respectively (IPCC, 2006). Many countries have determined a country specific factor. In 2014 Keliher et al. accounted in a statistical analysis of measurements of nitrous oxide emissions from 185 field sites in New Zealand and they concluded that the appropriate values of EF_3 in that country for dairy cattle urine and dung, and sheep urine and dung are 1.16%, 0.23%, 0.55% and 0.08%, respectively. The Brazilian Cattle herd is approximately 20 times greater and occupies 40 times more land then that country herd cattle and at the present a few papers were published reporting N_2O emissions. The mean EF_3 reported for the Brazilian conditions are 2.31%, 0.99% and 1.87% for cattle urine, dung and urine + dung (Table 2).

Table 2 N_2O emissions factor (%) from cattle excreta deposited on pasture in Brazilian conditions.

Location	Climate and Season	Excreta type	Emission factor	Reference
Curitiba-PR	Subtropical	Urine	0.15%	Sordi et al. (2013)
Curitiba-PR	Subtropical	Dung	0.26%	Sordi et al. (2013)
Santo Antônio de Goiás-GO	Tropical/ rainy season	Urine	1.93%	Lessa et al. (2014)
Santo Antônio de Goiás-GO	Tropical/ rainy season	Dung	0.14%	Lessa et al. (2014)
Santo Antônio de Goiás-GO	Tropical/ rainy season	Urine	0.1%	Lessa et al. (2014)
Santo Antônio de Goiás-GO	Tropical/ rainy season	Dung	0.0%	Lessa et al. (2014)
Seropédica-RJ	Tropical	Urine 1L	4.9%	Cardoso et al. (2016b)
Seropédica-RJ	Tropical	Urine 1.5L	3.36%	Cardoso et al. (2016b)
Seropédica-RJ	Tropical	Urine 2L	2.43%	Cardoso et al. (2016b)
Seropédica-RJ	Tropical	Dung	0.18%	Cardoso et al. (2016b)
Jaboticabal-SP	Tropical/ Rainy season	Urine	4.26%	This thesis
Jaboticabal-SP	Tropical/ Rainy season	Dung	2.34%	This thesis
Jaboticabal-SP	Tropical/ Rainy season	Urine + Dung	3.95%	This thesis
Jaboticabal-SP	Tropical/ Dry season	Urine	1.35%	This thesis
Jaboticabal-SP	Tropical/ Dry season	Dung	3.00%	This thesis
Jaboticabal-SP	Tropical/ Dry season	Urine + Dung	1.59%	This thesis
Means		Urine	2.31%	
		Dung	0.99%	
		Urine + Dung	1.87%	

Nitrous oxide options of mitigation for livestock production systems includes optimum soil and grazing land management, limiting the amount of N fertilizes or effluent applied when soil is wet, animals dietary management to decrease the amount of N excreted in animal urine through feeding low-N feed supplements as an alternative to fertilizer N boosted grass (USSIRI and LAL, 2013). Adoption of legumes that obtains N for biological nitrogen fixation, selection plant and animals to improve nitrogen use efficiency, use of inhibitors of N transformations and improve the animal performance to reduce the age of slaughter also can contributed for the reduction of N_2O emissions.

5. GAPS IN KNOWLEDGE

The main gap in knowledge in Brazilian conditions is to quantify CH_4 and N_2O to improve the greenhouse gas inventories and determining country-specific emission factor. A large variation in soils and climatic factors are observed in Brazil as well as peculiarities in the animal production.

Explore the micro-organism that are involved CH_4 and N_2O emissions and consumption are demanded. Identifying, isolating and exploring how they interact with soil and climatic factor.

Identifying the factors that control emissions and how the different environmental combinations influence the magnitude of the greenhouses source.

The factors regulating N_2O consumption in soil are not well understood. More studies in soil with different soil textures, mineral N content, porosity and soil moisture content are recommend to study the relationships between these soil parameters and N_2O consumption (MAZZETTO et al., 2014).

To calculate the impact of pasture restoration, adoption of integrated livestock-crop and integrated crop-livestock-forest system as well introduction of legumes in the GHG emissions.

Find the better protein to energy ratio to minimize N losses in the animal production. Selected and breeding for animals that maximizes N utilizations.

Study substances like hormones and growing stimulator for plant as strategy to mitigate N_2O emissions.

Outline the effect of Biochar application on the soil, improve nitrogen efficiency usage and cutting GHG emissions in grasslands.

Explore the life cycle assessment as a tool to evaluate different system of animal production on GHG emissions.

Study integrated options to improve animal performance although management, genetic and nutrition to reduce the time necessary to rise a beef cattle avoid GHG emissions.

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