



5<sup>th</sup> International Conference of the International  
Commission of Agricultural and Biosystems Engineering  
(CIGR)

Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)  
Virtually from Québec City, Canada – May 11-14, 2021



# Emissions from indoor and outdoor exercise areas for cows housed in tie stalls: factors and technics of measurement

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CHAIRE DE LEADERSHIP  
EN ENSEIGNEMENT  
des bâtiments agricoles durables  
de l'Université Laval



Systèmes de  
production évolutifs  
Contrôle avancé de  
l'environnement  
Gestion optimale des  
ressources et des effluents  
Efficacité énergétique  
et énergies alternatives



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# Context and background

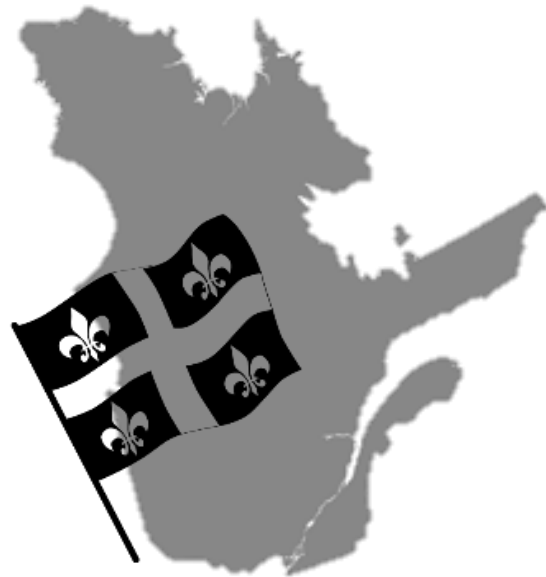
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# Dairy barns by type in Canada

<https://1bestlinks.net/q,J1MW>



Created by Charlotte Vogel  
from Noun Project

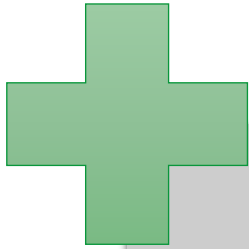
3,123 Dairy barns

91.4% Tie Stall

8.6% Free Stall

# Indoor or outdoor exercise?

## Indoor



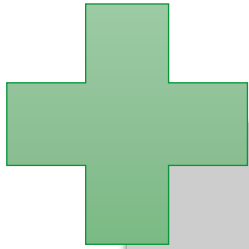
- Less damage claws
- Less risk of contracting white line disease

- Increased dystocia and endometritis
- Concrete → risk of lameness and foot infections



# Indoor or outdoor exercise?

## Outdoor

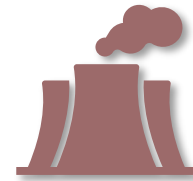


- Reduced lameness and knee injuries
- Strong preferences for more natural environments



- Damage claws
- More space → increased production of emissions (?)

# Environmental impact of dairy industry



GHG

3,7 % (QC) 1.3% (CA)



Carbon footprint

1.01 kg CO<sub>2</sub> eq



Water footprint

20 L



# Aim of the study



Quantify the GHG, and ammonia emissions produced in the outdoor and indoor exercise areas and compare them with the emissions produced in the stalls.



A photograph of a brown and white cow standing in a snowy enclosure. The cow is positioned behind a metal railing. To the left is a green wooden building. In the background, there is a chain-link fence and a snowy landscape under a clear blue sky.

# Methodology

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# Experimental site

🏠 This project was carried out in the Animal Science Research Centre of Deschambault (CRSAD), in Quebec, Canada



# Experimental setup and design



## Sampling locations:



Control stalls (1.8 x 1.5 m.)



Indoor pen (3.9 m x 7.2 m)



Outdoor pen A (5.3 m x 5.3 m)



Outdoor pen B (5.3 m x 5.3 m)



# Experimental setup and design

- 18 cows were grouped into three groups of 6 cows each
- 2 blocks (AM and PM) of 3 cows (Indoor, outdoor pen A and B)
- Sampling of **control stalls** during the morning outing.
- Sampling of **exercise pens**, upon return to stalls.

Sampling locations:



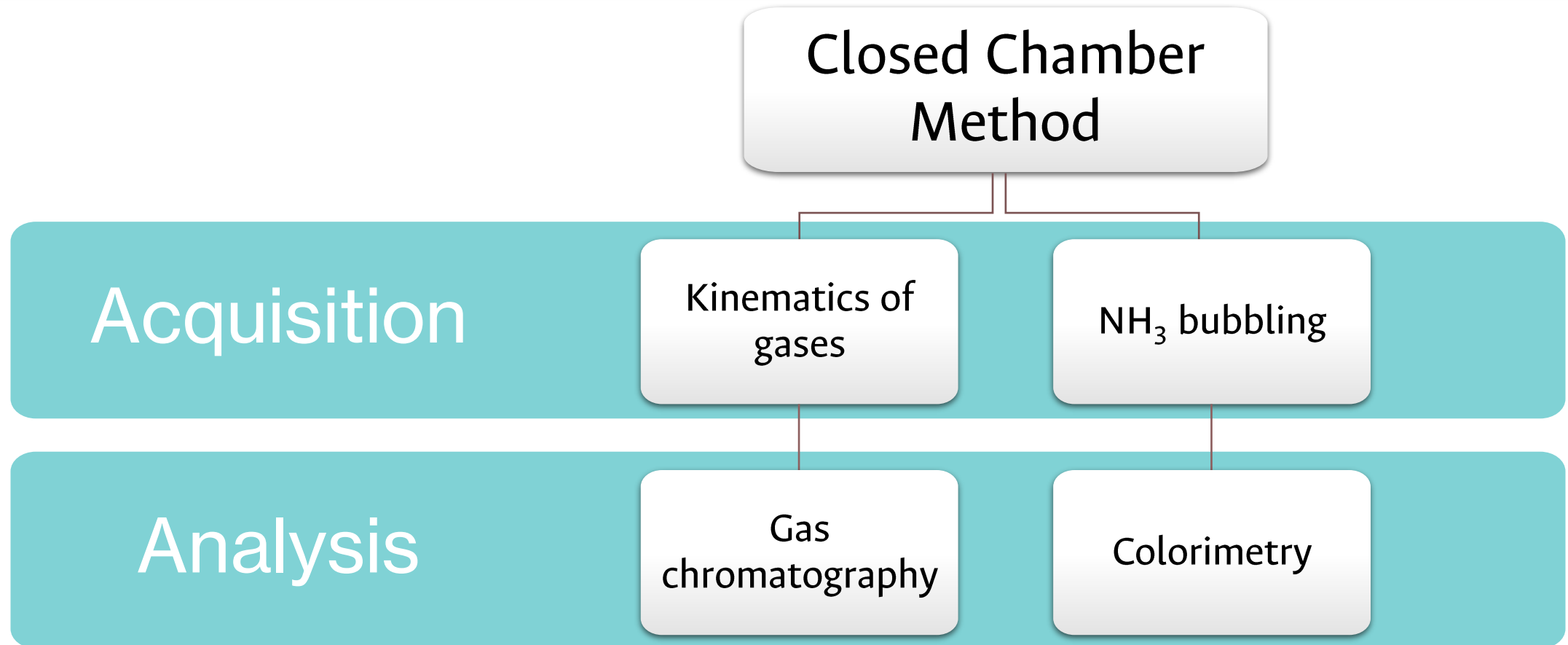
Control stalls (left) and indoor pen (right)



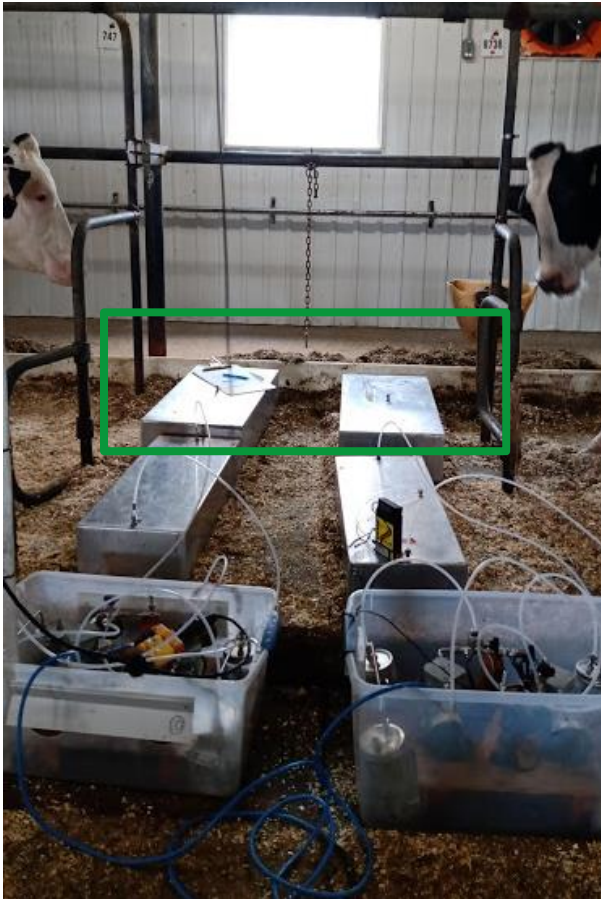
Pen A (left) and Pen B (right).



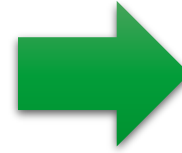
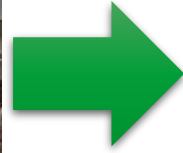
# Soil gas sampling



# GHG sampling



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# Ammonia sampling



Air duct

Closed chamber

Flowmeter

Acid Trap System

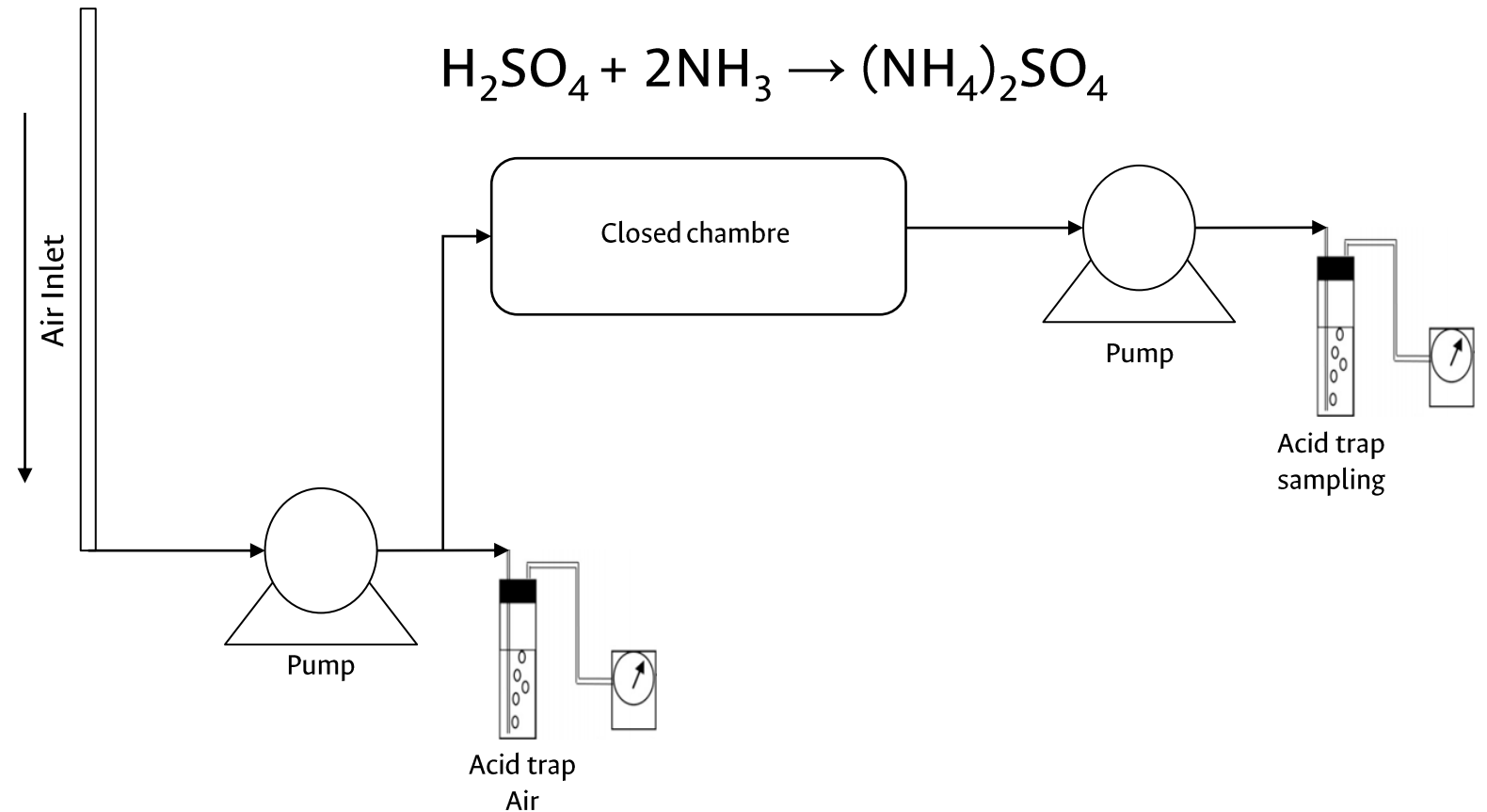
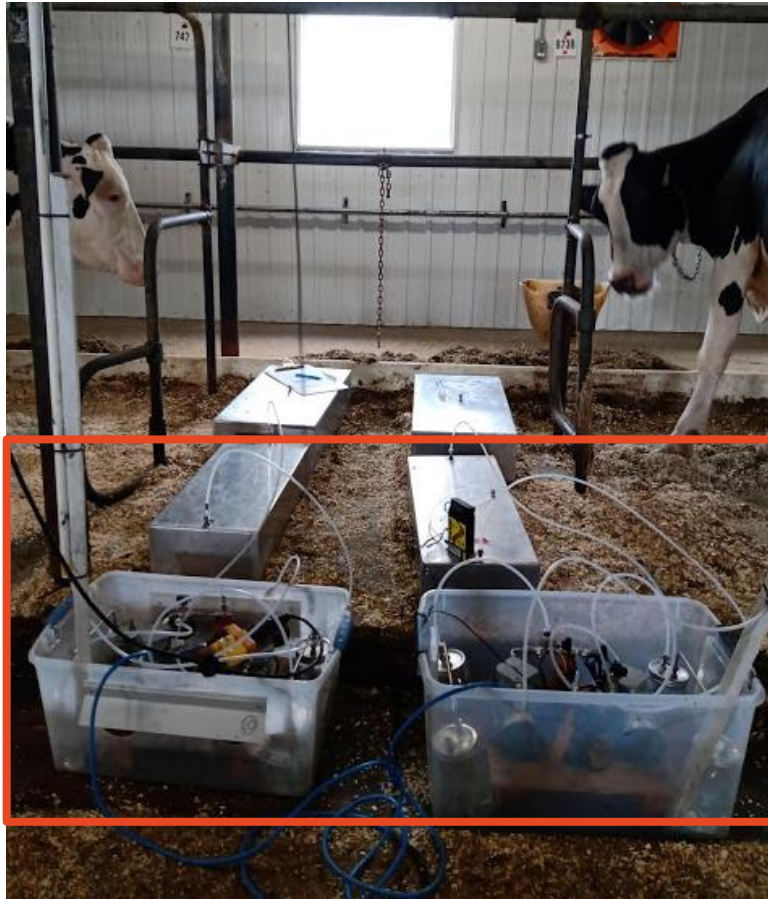


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# Ammonia sampling



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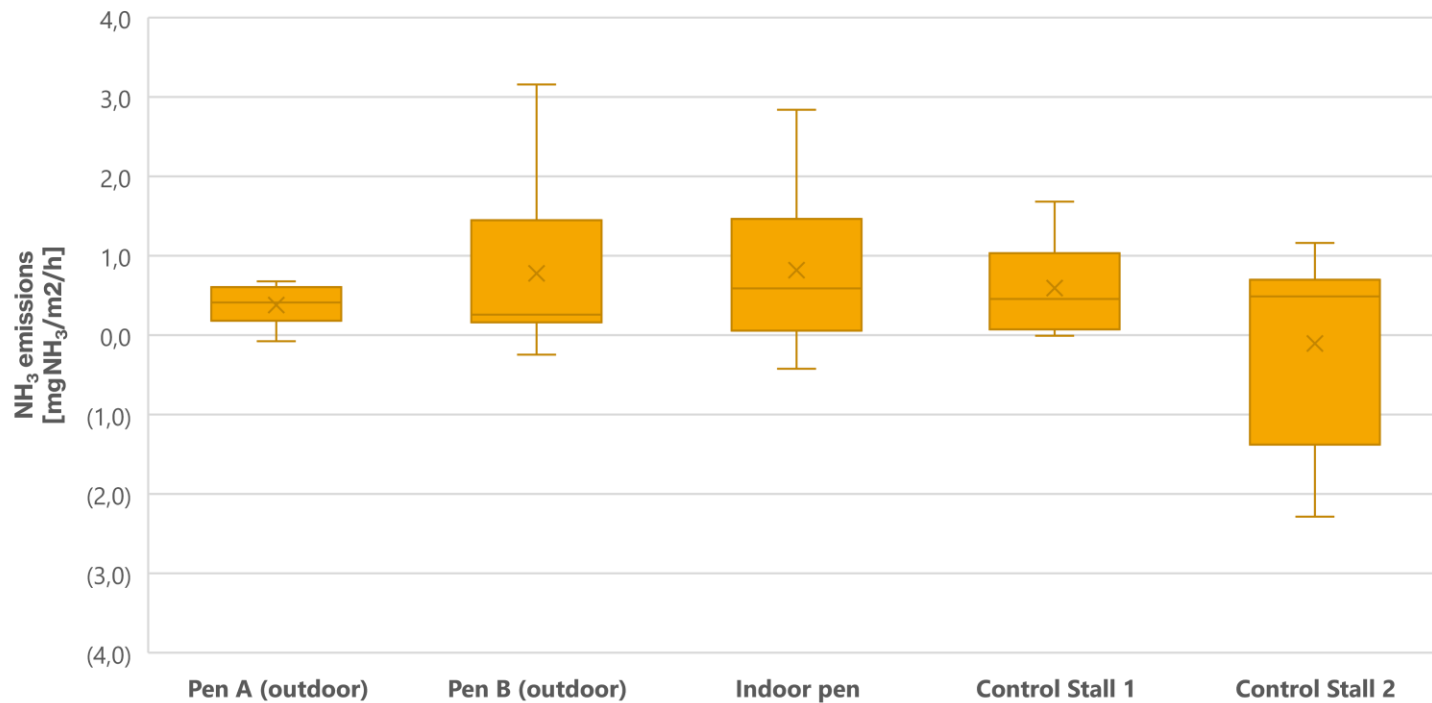
# Results

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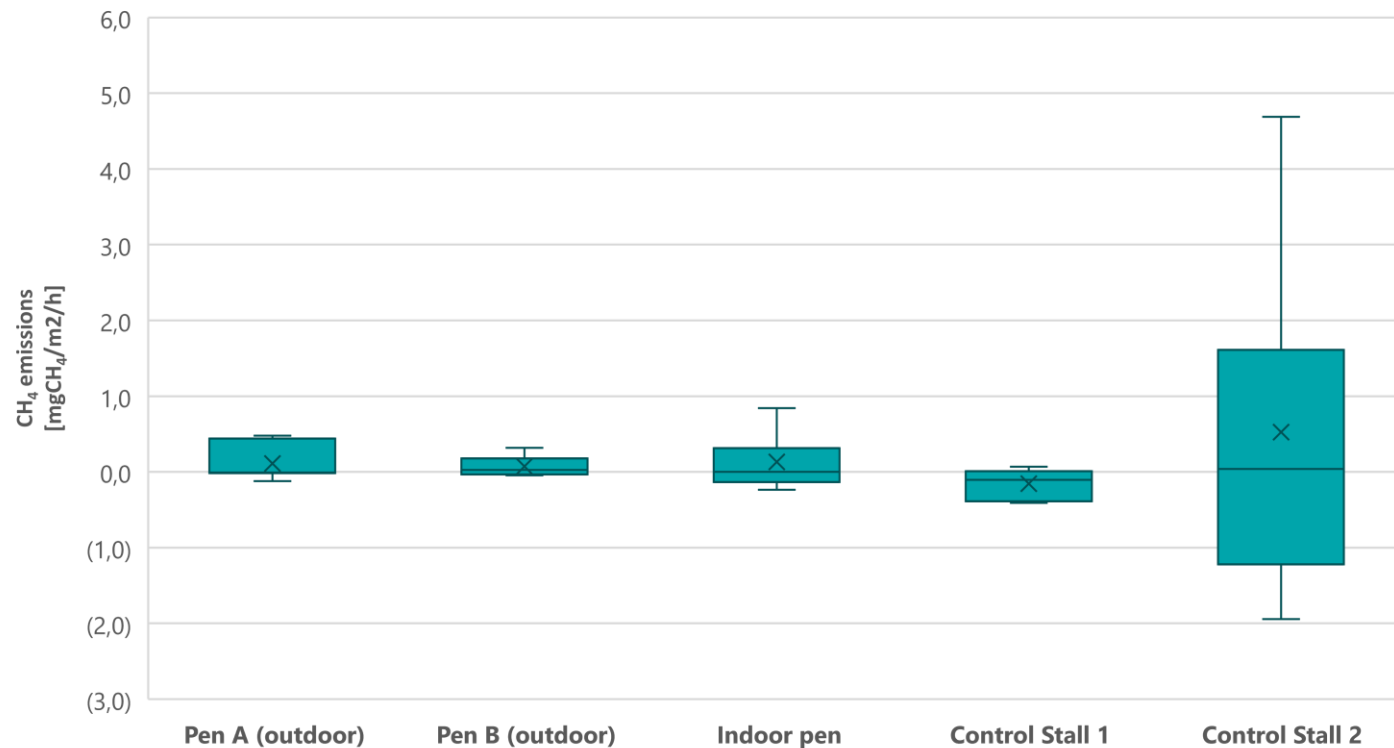


# Ammonia results



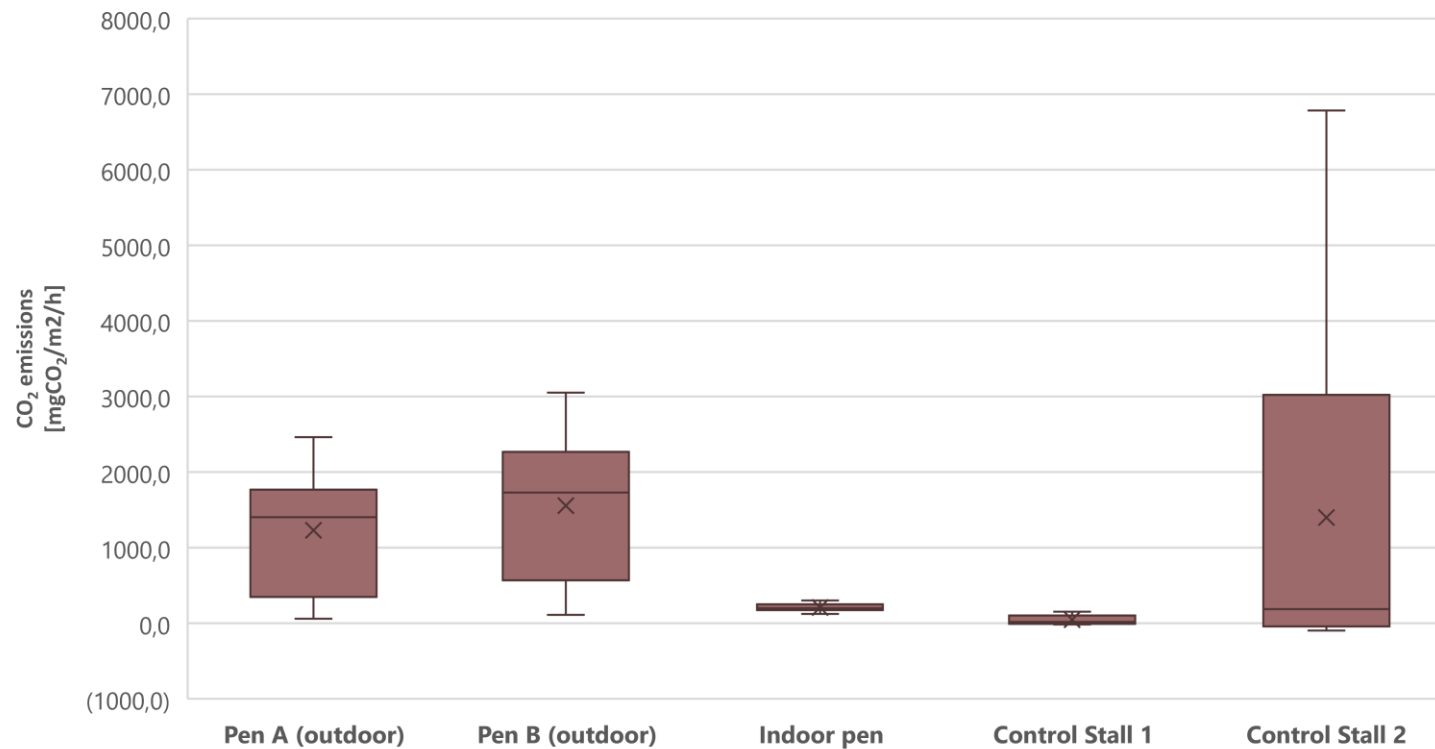
Location	NH <sub>3</sub> [mgNH <sub>3</sub> /m <sup>2</sup> /h]
Pen A (aerated)	0,38
Pen B (non aerated)	0,44
Indoor pen	0,82
Control Stall 1	0,59
Control Stall 2	(0,11)

# GHG results – Methane



Location	CH <sub>4</sub> [mgCH <sub>4</sub> /m <sup>2</sup> /h]
Pen A (aerated)	0,11
Pen B (non aerated)	0,07
Indoor pen	0,13
Control Stall 1	(0,15)
<b>Control Stall 2</b>	<b>0,52</b>

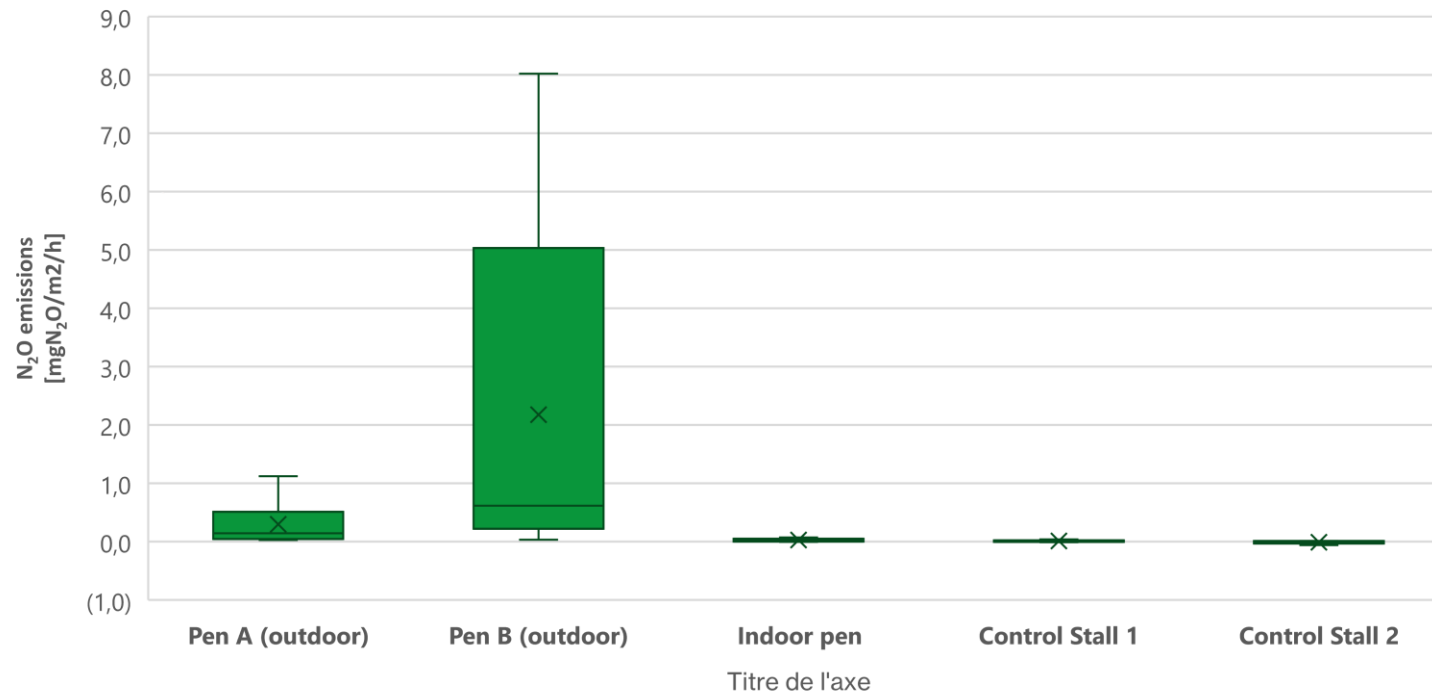
# GHG results – Carbon dioxide



Location	CO <sub>2</sub> [mgCO <sub>2</sub> /m <sup>2</sup> /h]
Pen A (aerated)	1228,10
<b>Pen B (non aerated)</b>	<b>1556,31</b>
Indoor pen	208,02
Control Stall 1	45,94
Control Stall 2	630,78



# GHG results – Nitrous oxide




Location	N <sub>2</sub> O [mgCO <sub>2</sub> /m <sup>2</sup> /h]
Pen A (aerated)	0,18
Pen B (non aerated)	2,17
Indoor pen	0,03
Control Stall 1	0,01
Control Stall 2	0,03

# Conclusions and Recommendations

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 Emissions in control stall similar to indoor stall and lower than outdoor stall (composting product).

 control stall → accumulated manure increased methane production.

 Due to the high variability of the data, a new measurement is recommended in order to be more certain.

# Acknowledgements

 PARTENARIAT  
CANADIEN pour  
l'AGRICULTURE



Canada



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**DAIRY  
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LAITIÈRE 3**



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# Thank you!