Methane and Ammonia Emissions from Tent Covered Manure Storage Tanks

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Tent Covered Manure Storage Tanks

- In Denmark:
  - 25-30% of manure storage tanks with pig manure
  - 10-15% of manure storage tanks with cattle manure
- Most widely used for manure storage tanks with pig manure and anaerobically digested manure because these types of manures do not tend to develop a natural surface crust.

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Tent Covered Manure Storage Tanks

A number of small ventilation openings are installed in the tent fabric to prevent explosion risk

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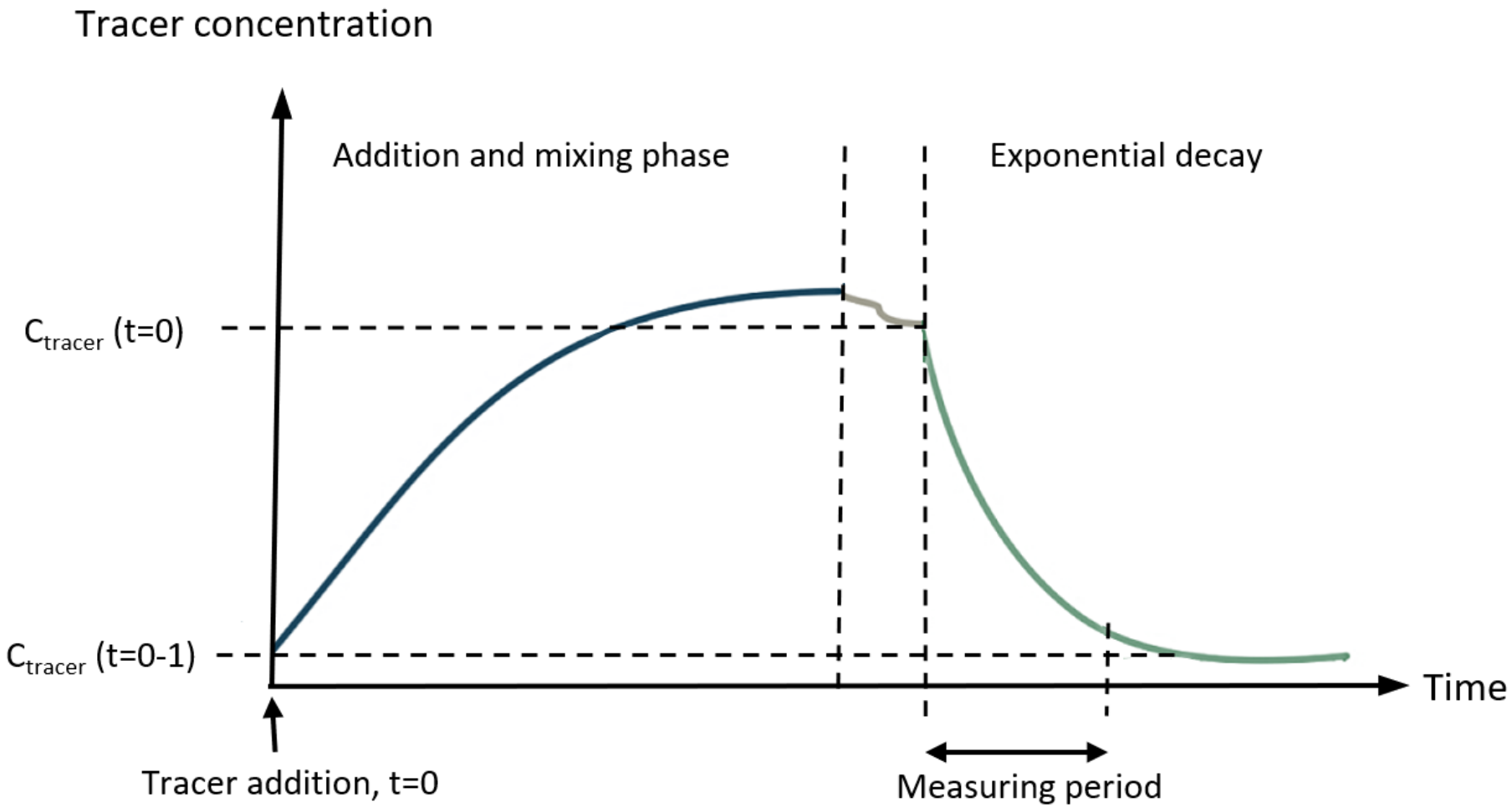
Air Exchange Rate - Tracer Decay Method



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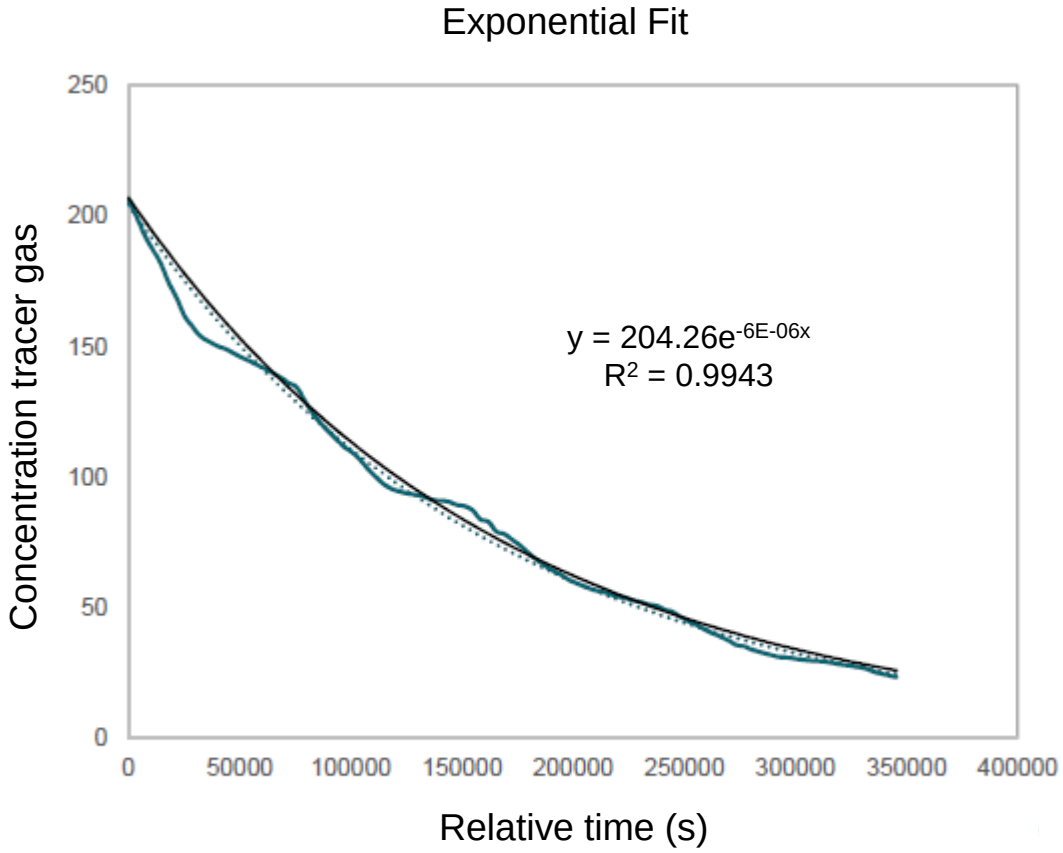

The air exchage rate is determined from the general mass balance for the tank:

$$V\frac{d(C(t))}{dt} = Q(t)\cdot\big(C(t) - C(o)\big)$$

$$N = \frac{\ln(C_o) - \ln(C_f)}{T}$$

The ventilation rate, Q, is determined

$$N = \frac{Q}{V}$$

And the emission is determined from the ventilation rate (Q) and measured concentrations

$$E_{NH_3} = Q \cdot C_{NH_3}$$

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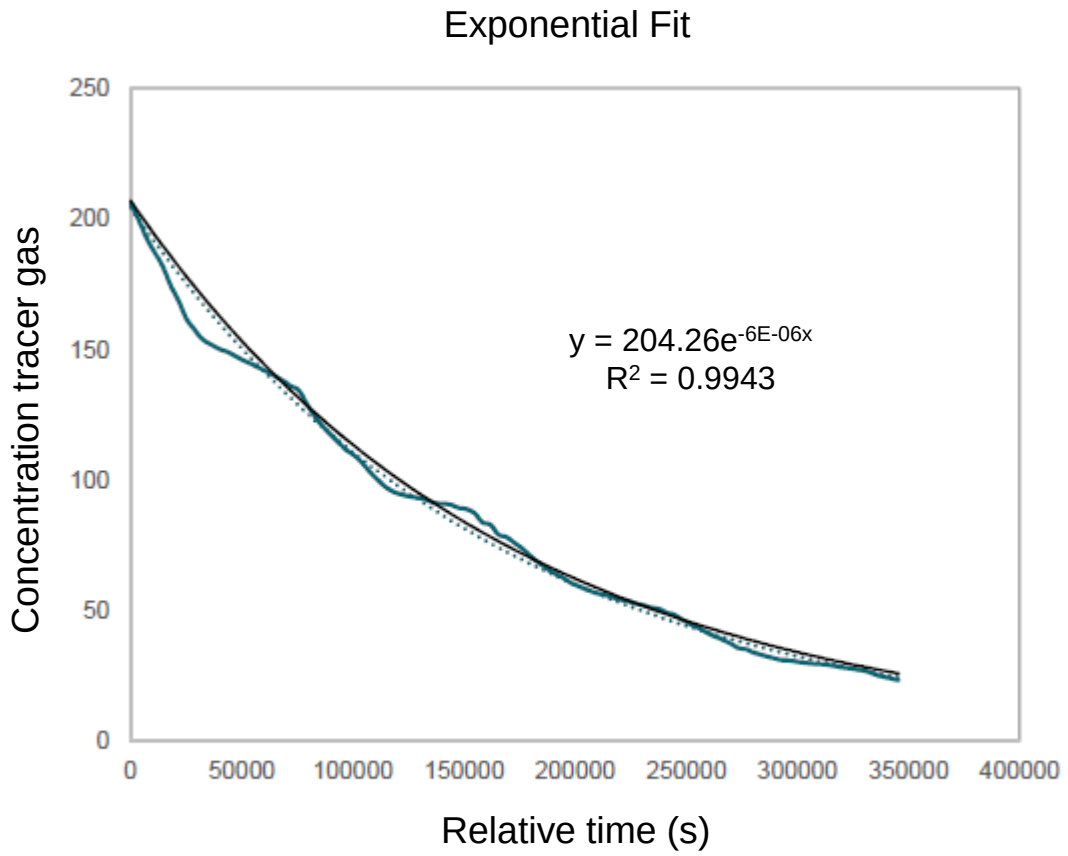

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➡ Nitrous oxide, N_2O, used as traser gas

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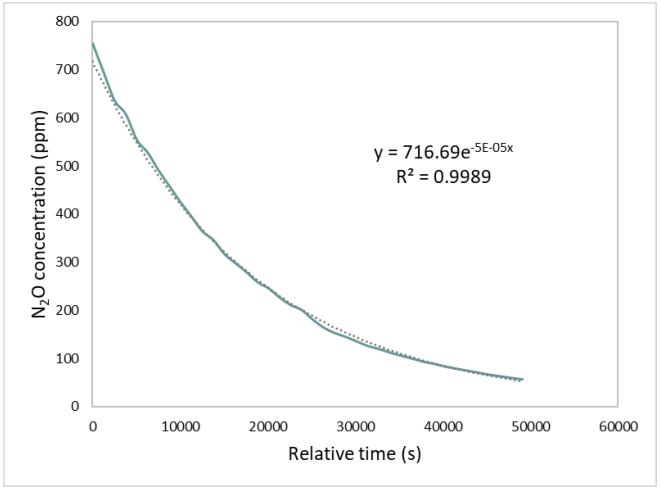
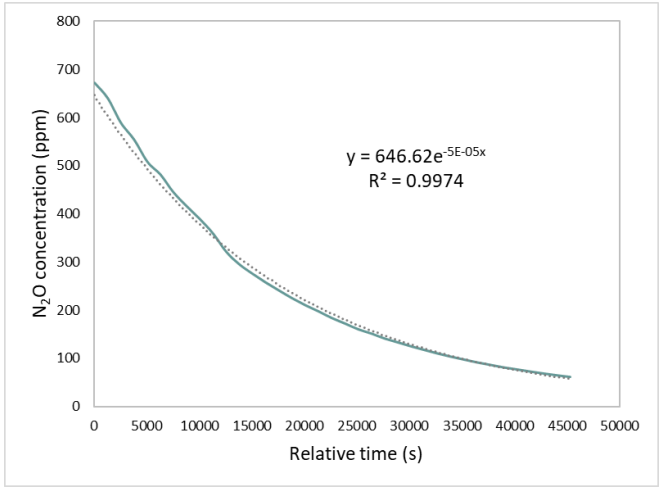
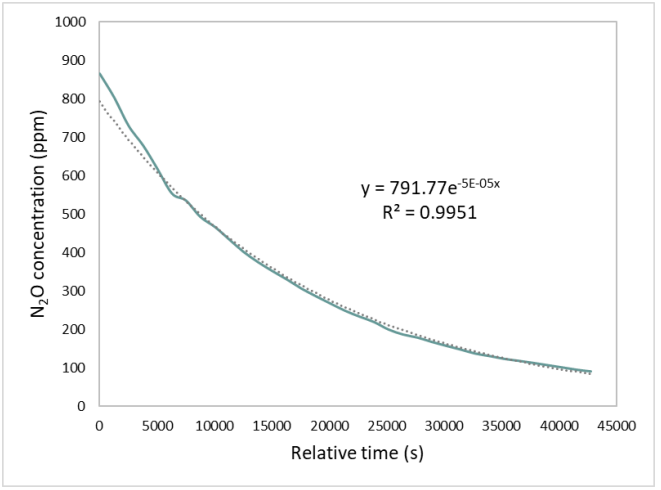
Method Validation

- Method validated in 25 m^3 tanks with fixed flow
- 3 repetitions
- Average difference between setpoint flow and flow estimated with tracer decay method (N_2O) - 4.9 $\pm$ 0.9 %







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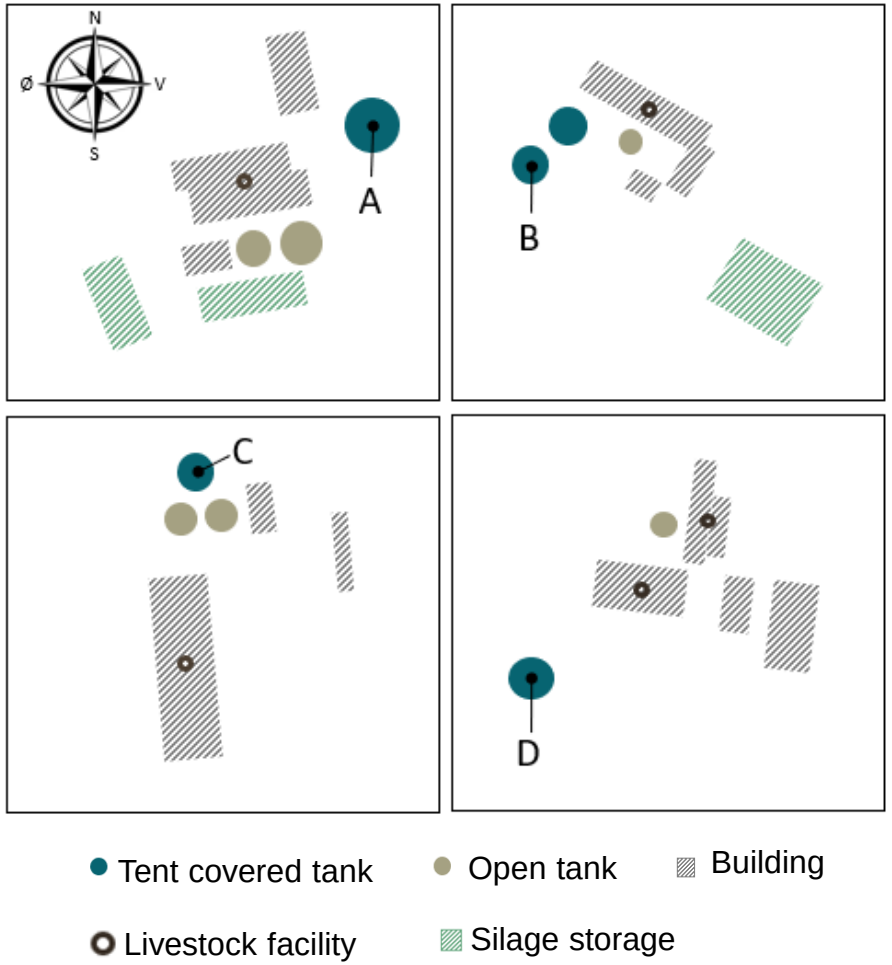
Manure Storage Tanks

	Animal type	Volume Tank m^3	Volume Tent m^3	Surface area m^2
A	395 cows 58 heifers (Dansk Holstein)	5019	2390	1068
B	285 cows 188 heifers (Dansk Holstein)	3003	955	651
C	1150 sows	2380	860	540
D	9500 finisher pigs	3488	1580	812



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Measuring Points

- Difference between measuring points < 3-4%

- Ammonia measured by CRDS (Picarro)
- Methane measured by CRDS (Picarro), PAS (Innova), IR (GMC biogas 08), GC
- Nitrous oxide measured by PAS (Innova)

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Nitrous Oxide

	Season	N days	N_2O before tracer addition (±STD) ppm	Min/max N_2O before tracer addition (±STD) ppm	N_2O tracer lower limit ($\bar{x} + 3 \cdot STD$) ppm	Avg. Exponential fit (R^2)	Wind m s^{-1}	Temp °C	pH -	Ventilation rate m^3 h^{-1}
A	Summer	17	10.1±0.1	9.9/10.1	10.3	0.98	3.5 ± 1.5	14.0 ± 2.8	7.05	173.1 ± 33.1
	Autumn	14	8.3±0.03	8.2/8.4	8.4	0.99	3.8 ± 1.4	8.7 ± 2.5	6.95	156.0 ± 74.0
	Winter	10	8.3±0.04	8.3/8.4	8.4	0.98	4.4 ± 1.1	5.6 ± 1.8	6.96	157.6 ± 36.7
	Spring	13	8.3±0.5	8.2/8.3	8.4	0.89	4.7 ± 1.8	7.9 ± 3.7	6.96	179.6 ± 85.1
B	Summer	14	0.7±0.05	0.1/1.9	2.3	0.99	3.5 ± 1.7	14.2 ± 2.6	-	69.1 ± 1.7
	Autumn	24	8.0±0.05	7.9/8.1	8.2	0.96	4.1 ± 1.6	5.4 ± 1.6	6.88	66.4 ± 18.9
	Winter	10	8.3 ±0.07	8.2/8.5	8.5	0.99	4.9 ± 1.4	-2.1 ± 1.7	6.98	38.9 ± 6.9
	Spring	11	9.2±0.5	8.3/10.1	10.8	0.98	3.8 ± 1.4	7.6 ± 4.4	6.96	55.4 ± 8.3
C	Summer	26	56.9±8.7	34.0/70.5	83.0	0.96	2.6 ± 0.8	23.7 ± 4.1	6.95	31.3 ± 14.9
	Autumn	14	50.2±2.7	45.6/54.4	58.4	0.99	4.6 ± 1.4	12.9 ± 1.3	7.46	43.0 ± 0.0
	Winter	13	24.2±0.3	23.7/24.6	25.1	0.99	3.8 ± 1.4	2.3 ± 1.4	-	35.6 ± 38.7
	Spring	10	89.8±12.2	43.3/112.1	126.5	0.95	5.4 ± 2.0	2.4 ± 2.4	-	38.7 ± 20.4
D	Summer	17	24.8±7.01	14.0/41.3	67.5	0.97	4.3 ± 1.9	15.8 ± 3.1	7.58	87.5 ± 24.0
	Autumn	21	68.8±21.9	12.0/107.2	134.6	0.98	3.6 ± 1.4	14.0 ± 1.9	7.70	63.4 ± 15.8
	Winter	20	8.8±0.2	8.4/9.2	9.4	0.96	3.7 ± 0.7	9.5 ± 1.0	-	111.8 ± 2.3
	Spring	7	7.0±0.3	6.2/7.5	8.0	0.99	3.7 ± 1.4	8.9 ± 2.3	7.88	178.4 ± 0.6

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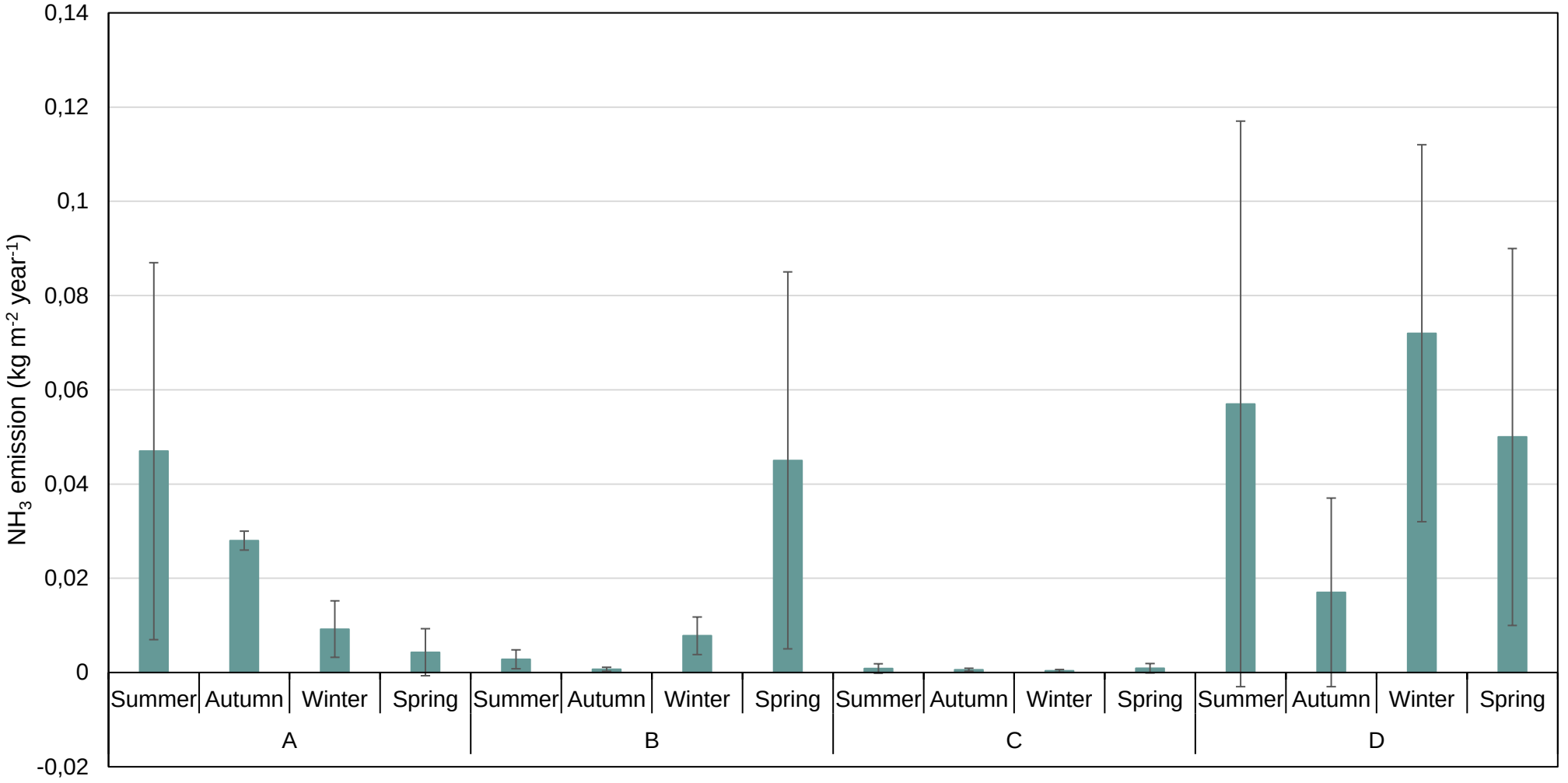
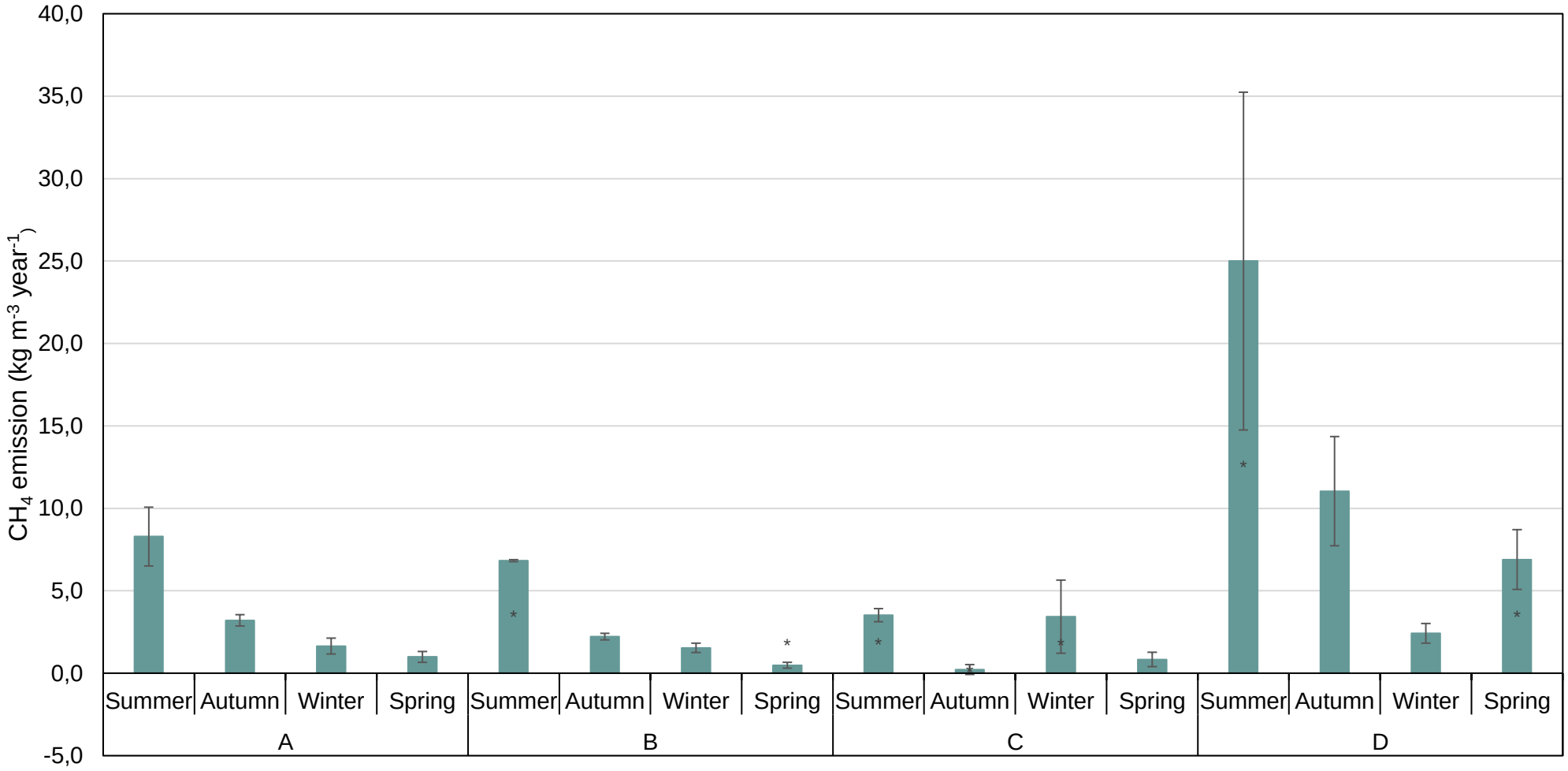
Ammonia


0,14
0,12
0,1
0,08
0,06
0,04
0,02
0
-0,02
NH3 emission (kg m-2 year-1)
Summer
Autumn
Winter
Spring
A
B
C
D

Methane


40,0
35,0
30,0
25,0
20,0
15,0
10,0
5,0
0,0
-5,0
CH4 emission (kg m-3 year-1)
Summer
Autumn
Winter
Spring
A
B
C
D

Conclusion

- Tracer decay method was successfully applied
- Ammonia emissions were lower than expected
- Methane emissions were higher than expected
- Nitrous oxide?

Further work

- 10 tent covered manure storage tanks to be measured 2022-2024 (cattle manure, pig manure, anaerobically digested manure and acidified manure)
- Different tracer gas (HFC134a?)
- Technologies to reduce greenhouse gas emissions from storage tanks

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