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A Process-based Approach for Ammonia Emission Measurements at a Free-stall Dairy

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Introduction

- ✓ AFOs and Fertilizer applications contribute large amount of NH_3 to atmosphere.
- ✓ NH_3 is a precursor to $PM_{2.5}$
- ✓ Need to quantify NH_3 emissions from low level area source (LLAS).
- ✓ NH_3 emissions may be regulated in future.

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Study Objective

- ✓ Estimate real-time NH_3 emissions from LLAS using a flux chamber protocol.

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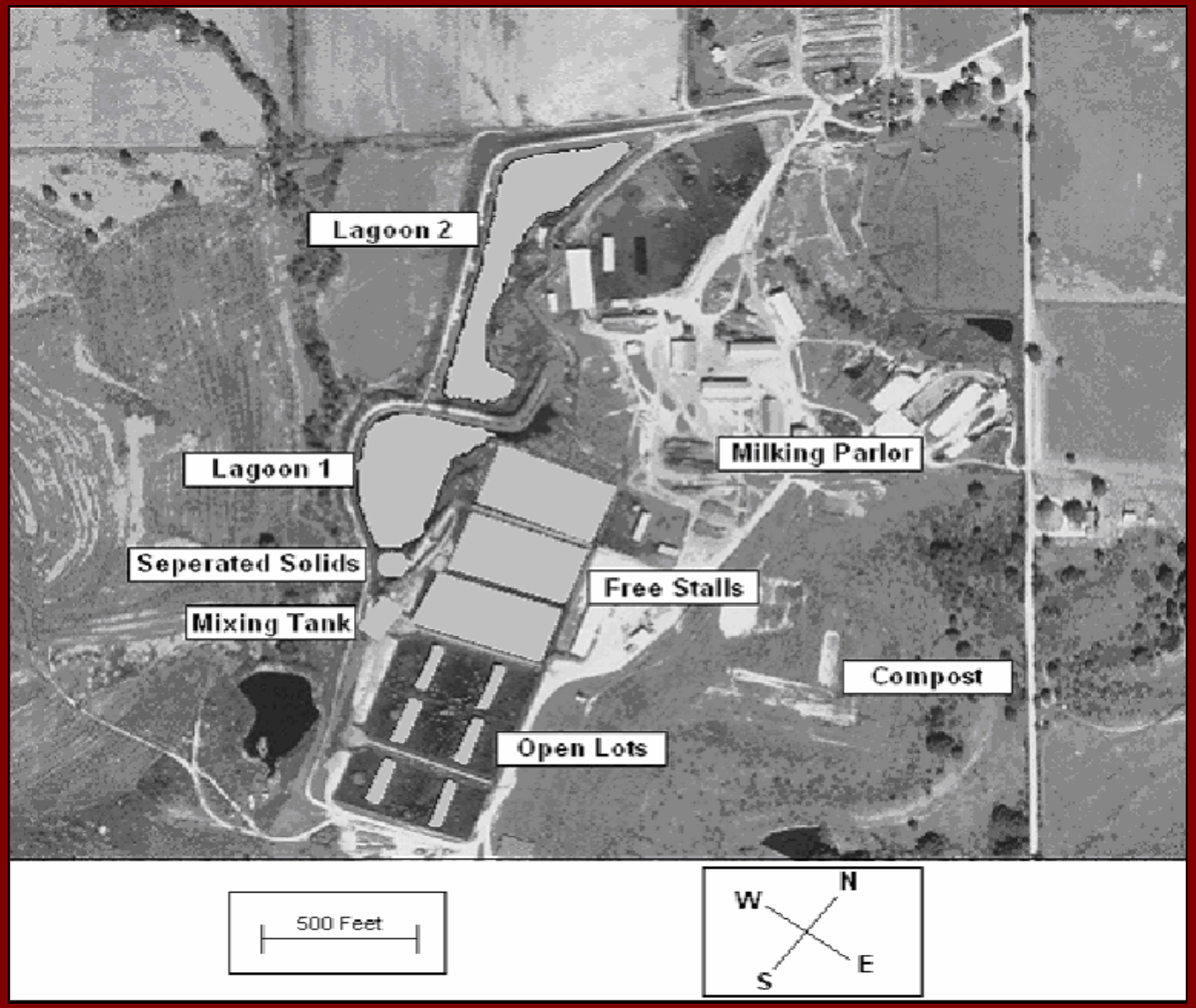
Sampled Dairy & LLAS



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Sampling Equipment

Flux Chamber

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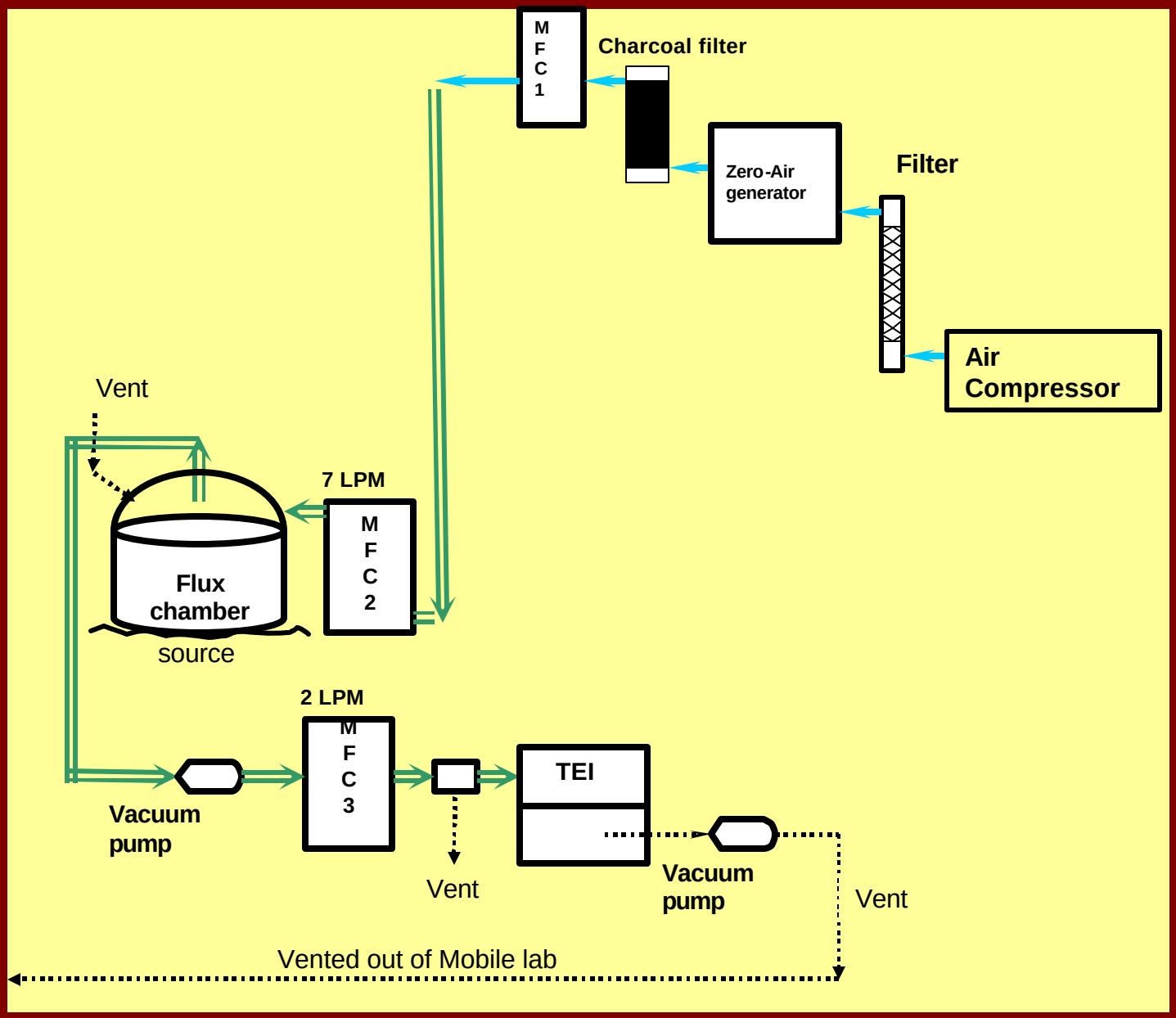
Flux Chamber & Analyzer Setup



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Freestall Sampling

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Lagoon Sampling

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Open Lot Sampling

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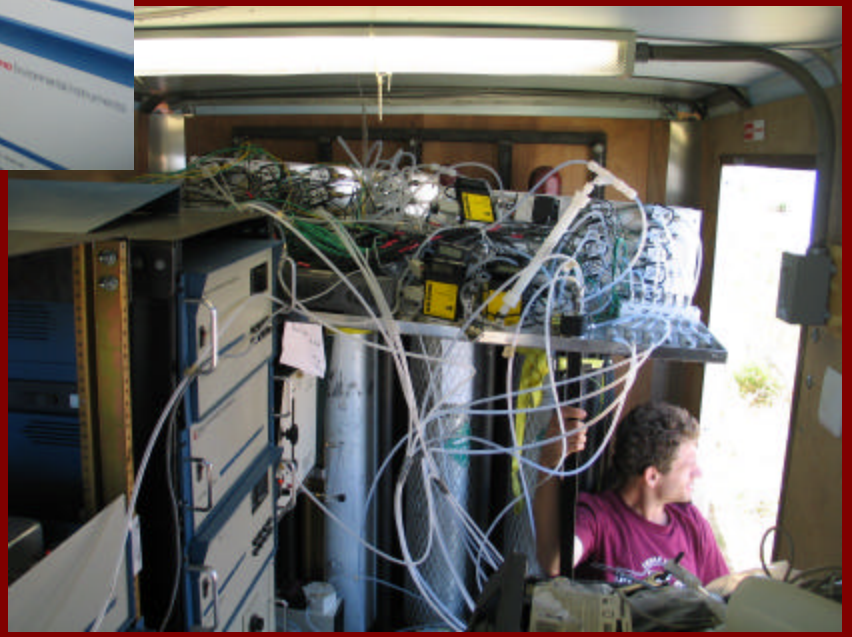
Mobil-Lab Views



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NH_3 Flux & Emission Rate Calculations

$$C_{mass} = 1000 \times \left(\frac{P}{RT} \right) \times C_{ppm} \times MW_p$$

$$EFl_{NH_3} = \frac{C_{mass} \times V_{fc}}{A_{FC}}$$

$$ER = EFl x A_s$$

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NH_3 Concentrations & ER for 2003 Winter

LLAS	Number of Samples	Concentration (ppm)	Concentration ($\mu g/m^3$)	E. Flux ($\mu g/ m^2/ s$)	Area (m^2)	ER (kg/day)	LLAS Temp (°C)	Ambient Temp (°C)
Compost	3	17.4 ± 23.5[b]	12120	5.3 ±7.1[b]	21000	9.5 ±12.9[b]	30.1	8.5
Free Stall	5	36.4 ±23.3	25354	11.0 ±7.0	9790	9.3 ±6.0	6.4	6.3
Dry Open Lot	3	6.5 ±8.8	4527	2±2.7	26000	4.4 ±6.0	-1.0	-1.0
Wet Open Lot	4	14.1 ± 5.4	9821	4.3±1.6	1400	0.5 ±0.2	-1.0	-1.0
Separated Solids	2	9.3 ±7.9	6478	2.8 ±2.4	110	0.03 ±0.02	3.6	3.7
Lagoon 1	6	2.0 ±0.5	1393	0.6 ±0.2	14000	0.7 ±0.2	8.7	16.7
Lagoon 2	6	0.4 ±0.3	279	0.1 ±0.1	16000	0.2 ±0.1	9.5	13.0
Statistics	29[a]				88300[a]	24.7[a] ±25.4[b]	8.0[c]	6.6[c]

[a] Summation

[b] 95% confidence interval (CI)

[c] Average

LLAS: Low Level Area Sources

E.Flux: NH_3 Emission Flux

ER: NH_3 Emission Rate

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NH_3 Concentrations & ER for 2003 Summer

LLAS	Number of Samples	Concentration (ppm)	E Flux ($\mu g/m^2/s$)	Area (m^2)	ER (kg/day)	LLAS Temp. °C	Ambient Temp.°C
Compost	11	1.9 ±1.6[b]	0.81 ±0.7 [b]	16600	1.17 ±0.97 [b]	43.17 ±7.1[b]	33.34 ±1.6 [b]
Freestall	14			9790			
Non-feed	5	57.5 ±50.5	20.53 ±23	2700	4.79 ±5.4	25.79 ±3.16	33.38 ±1.33
Feed	5	74.0 ±72.4	31.75 ±31	3090	8.48 ±8.3	33.91 ±56.1	34.60 ±0.2
Bedding	2	2.4 ±22.2	1.05 ±9.5	3800	0.34 ±3.1	27.02 ±2.78	33.34 ±3.14
Water Area	2	21.7 ±84.4	9.30 ±36.2	200	0.16 ±0.63	23.79 ±2.07	34.53 ±2.76
Open Lot	8	4.8 ±3.9	2.05 ±1.7	38000	6.72 ±5.5	30.63 ±3.5	33.27 ±1.43
Crowding Area	4	9.6 ±8.2	4.06 ±3.4	925	0.32 ±0.3	21.54 ±1.0	25.62 ±1.0
Separated Solids	4	3.7 ±7.2	1.50 ±2.9	109	0.01 ±0.03	34.01 ±5.2	-
Lagoon 1	8	32.8 ±7.1	14.09 ±3.0	19200	23.4 ±5	29.48 ±1.2	29.61 ±2.3
Lagoon 2	6	28.1 ±2.9	12.07 ±1.3	17000	17.72 ±1.9	28.42 ±0.7	26.67 ±1.9
Statistic	55[a]	-	-	101624[a]	63.1 [a] ±31.1		

[a] Summation

[b] 95% confidence interval (CI)

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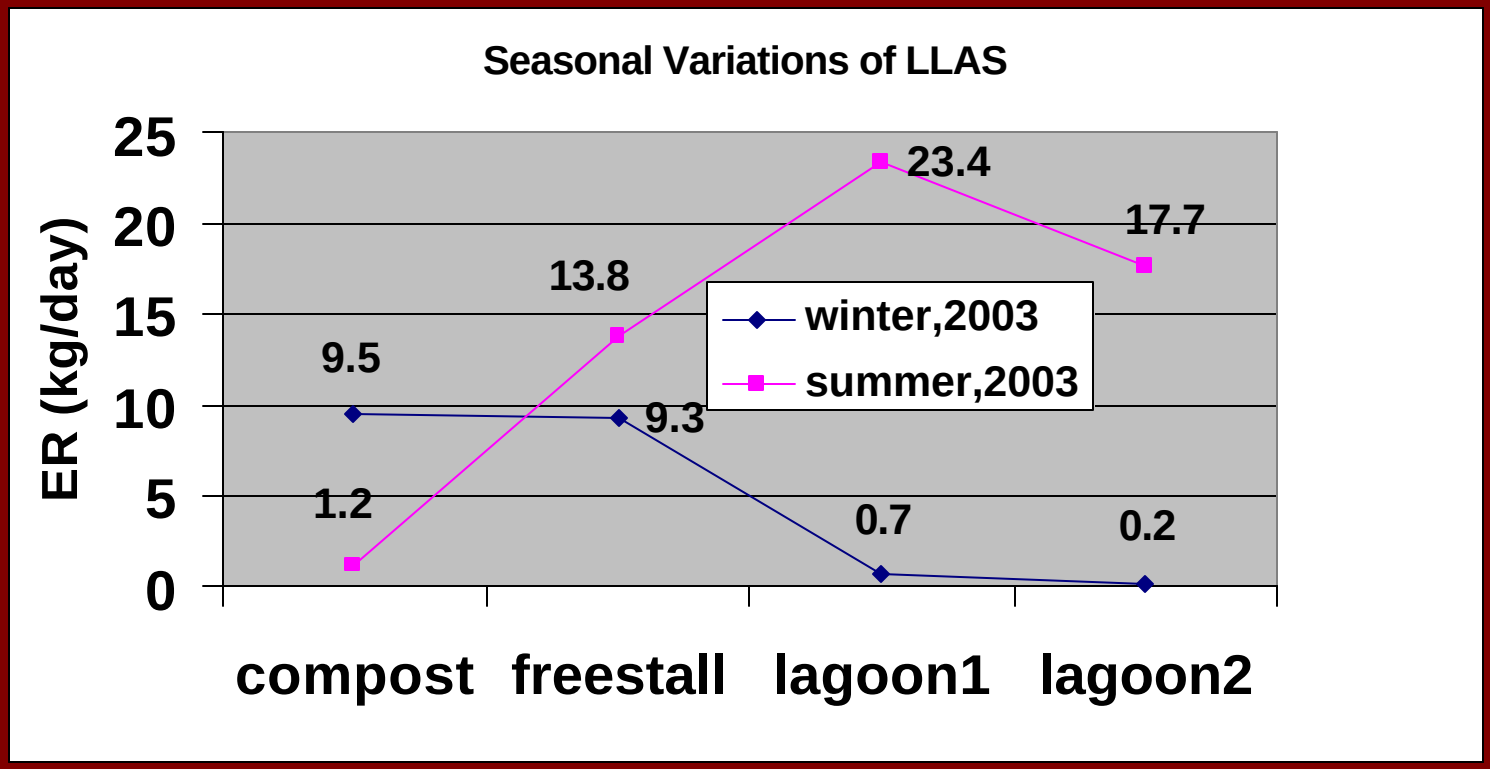
Seasonal NH_3 ER Variations of LLAS



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Key Results

- ✓ The estimated emission rates for the facility:
  24.7±25.4 kg.day^{-1} (winter).
  63.1 ±31.1 kg.day^{-1} (summer).
- ✓ The uncertainty of sampling system was 9.4%
- ✓ In the winter, compost and free-stall contributed 77% to overall NH_3 emission.
- ✓ In the summer, two lagoons contributed 65% to overall NH_3 emission at the dairy.

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Conclusions

- ✓ NH_3 emissions may vary due to:
  - *1- Seasonal variations in the temperatures,*
  - *2- Dairy waste loading rates,*
  - *3- Biological activity of LLAS*.
- ✓ Long-term studies needed to examine the impact of management practices on reducing NH_3 emissions from AFOs.

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