GREENHOUSE GASES FROM CATTLE SLURRY IN FULL-SCALE STORAGE DURING SUMMER

– crust treatments to reduce nitrous oxide emissions

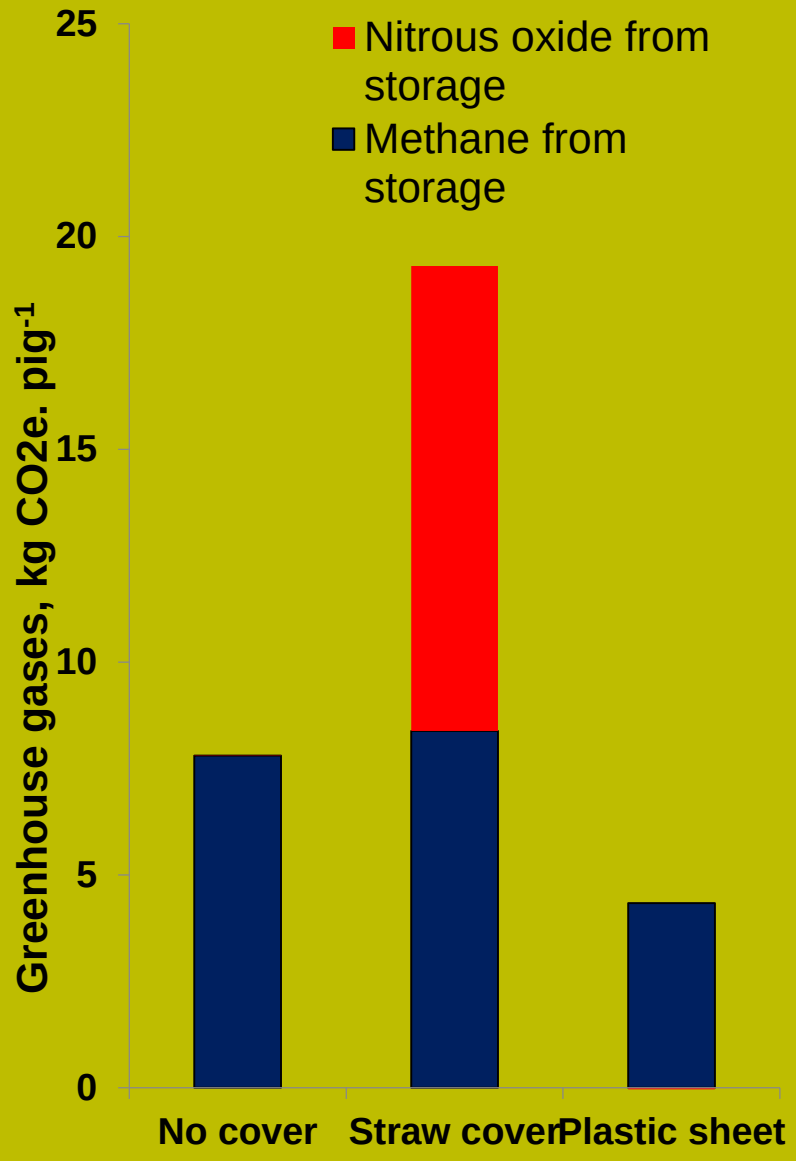
Lena Rodhe, Ass. Prof.; Johnny Ascue,
Adam Alverbäck and Åke Nordberg

Research Institutes of Sweden

RISE Agrifood and Bioscience

Background: Straw crust and N_2O from straw crust

- Straw crust is the main mitigation method to reduce ammonia emissions from storage (95%).
- Nitrous oxide (N_2O) emissions from stored slurry with a straw crust can exceed methane (CH_4) emissions in global warming potential (pilot scale studies).
- Less air in straw crust may reduce N2O-formation (Sommer et al., 2000).
- Manure surface treatment with sulphuric additive can decrease N_2O emissions (Gioelli et al., 2016).



- Rodhe et al., 2015

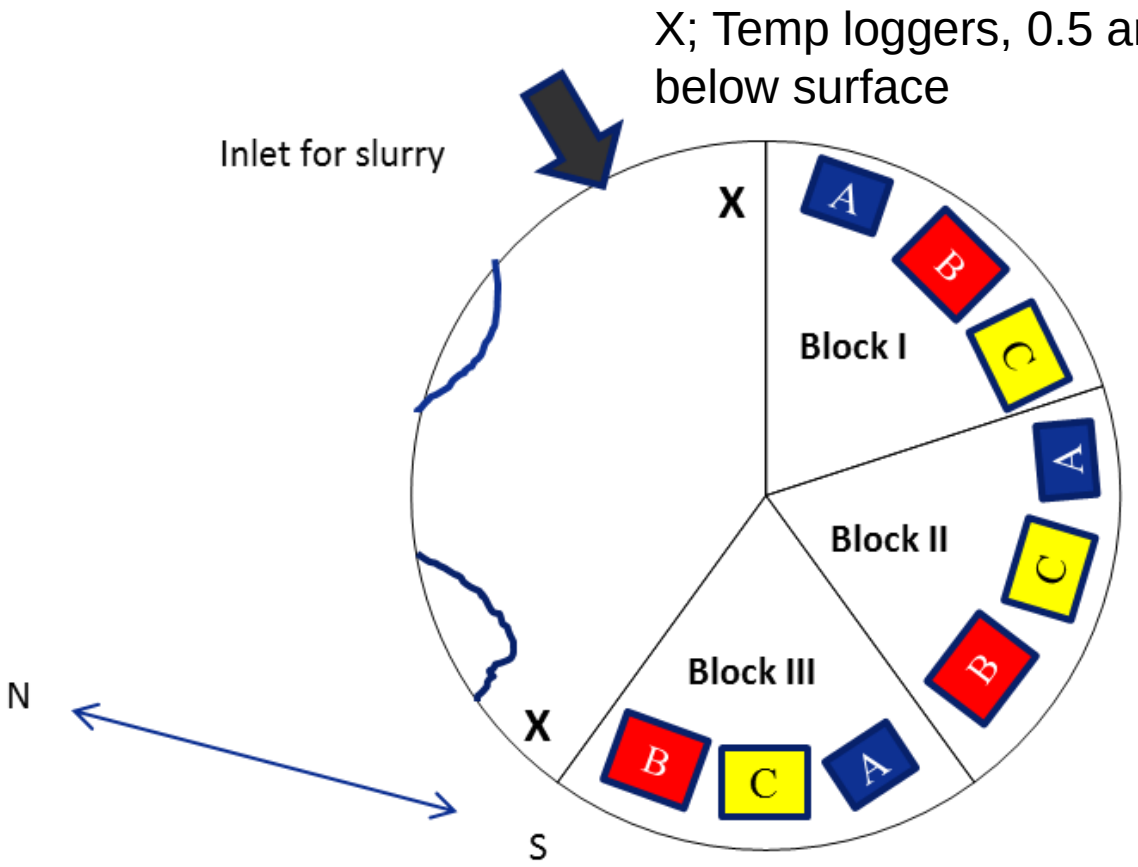
Hypothesis and aims

- This study tested the hypothesis that treating the straw crust with
  (1) water or
  (2) acid
  reduces N_2O emissions.
- A dynamic chamber technology was also evaluated.

Aims: find methods to reduce N2O from straw crust covered storages and methodology for measuring GHGs working in full scale.

Material and Methods (complete randomised block design with three blocks)

In full-scale storage of cattle slurry, emissions of N_2O, methane (CH_4) and carbon dioxide (CO_2) were measured at nine occasions from May to September (111 days) with a dynamic chamber.



Floating frames, treatments

A — Natural crust, without treatment

B — Natural crust, moisture

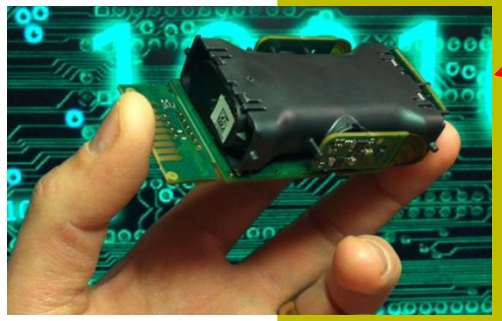
C — Natural crust, acid **(sulphuric acid), pH <2**

<u>Storage</u>
Volume: 2000 m^3
Depth: 3 m
Diameter: 29.2 m

Median chopped straw length: 23 mm

Material and Methods: Emission measurements

- Open dynamic chamber with frame and enclosure. The measuring chamber (enclosure) was moved between floating frames when measuring.
- Frame dimensions 1.03 m x 0.53 m (0.55 m^2), height 0.35 m (same as VDI-chamber). Pressed 0.1 m into surface crust.
- Air inlet designed as a slot placed in one end of the enclosure, and outlet chimney in the other end.
- Air exchange 2 times per minute, air speed 0.04 m/s above surface.
- Air samples sucked from chimney to CH4 sensor based on IR-technology and gas sampling point (analysed on GC for CH_4, N_2O and CO_2).
- Daily mean and cumulative emissions were calculated for the season.



SenseAir®AB

Air samples to CH_4 sensor and sampling point

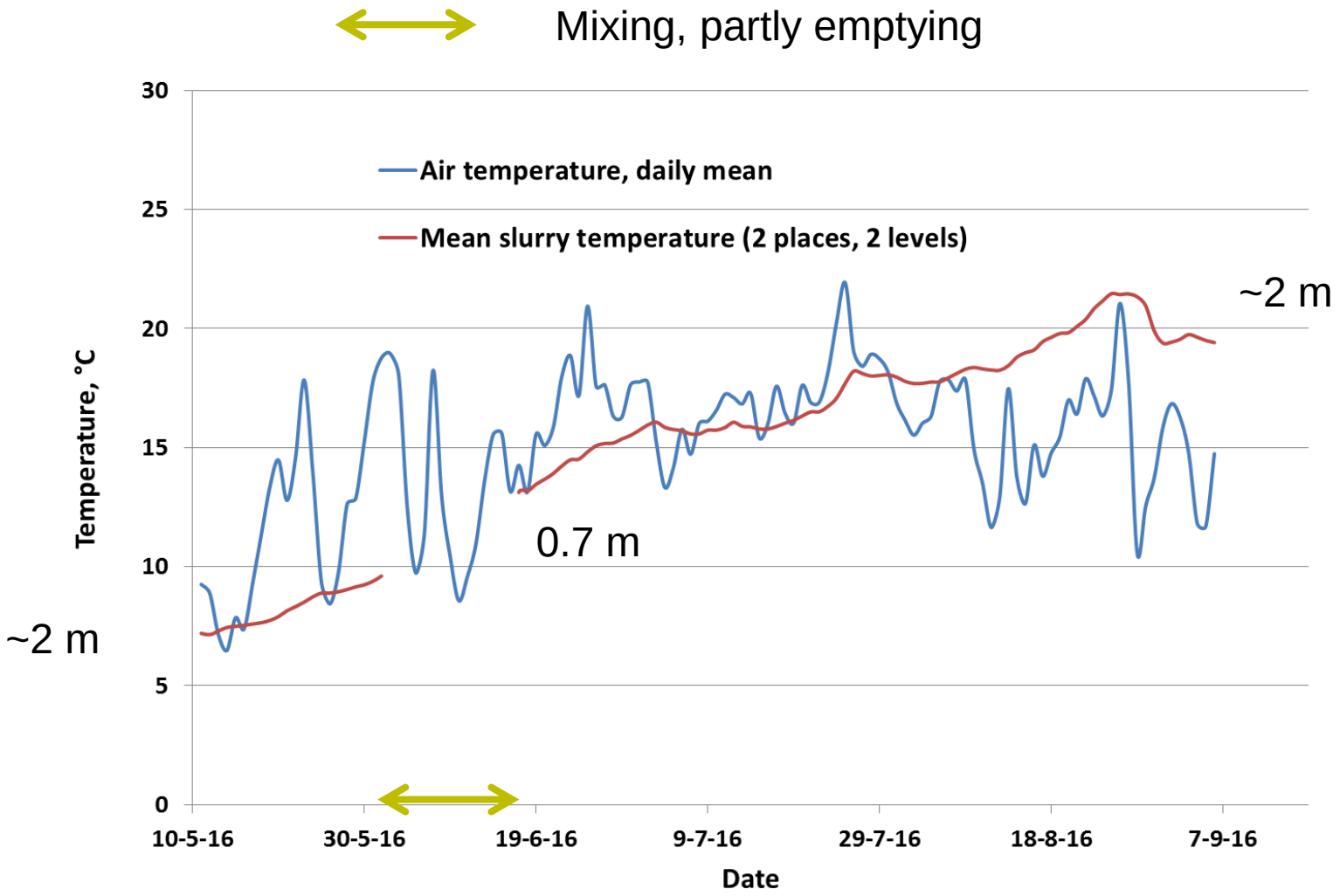
Slurry properties: after mixing, end of study

			Kg per tonne^{-1} (wet basis)					
TS, %	VS, %	**pH**	Tot-N	TAN	Tot- P	Tot- K	Tot-C	Tot-C/Tot-N
5.4	4.1	7.4	2.4	1.1	0.4	2.7	22.4	9.5

Straw crust thickness: 0.2 to 0.6 m during measurements.

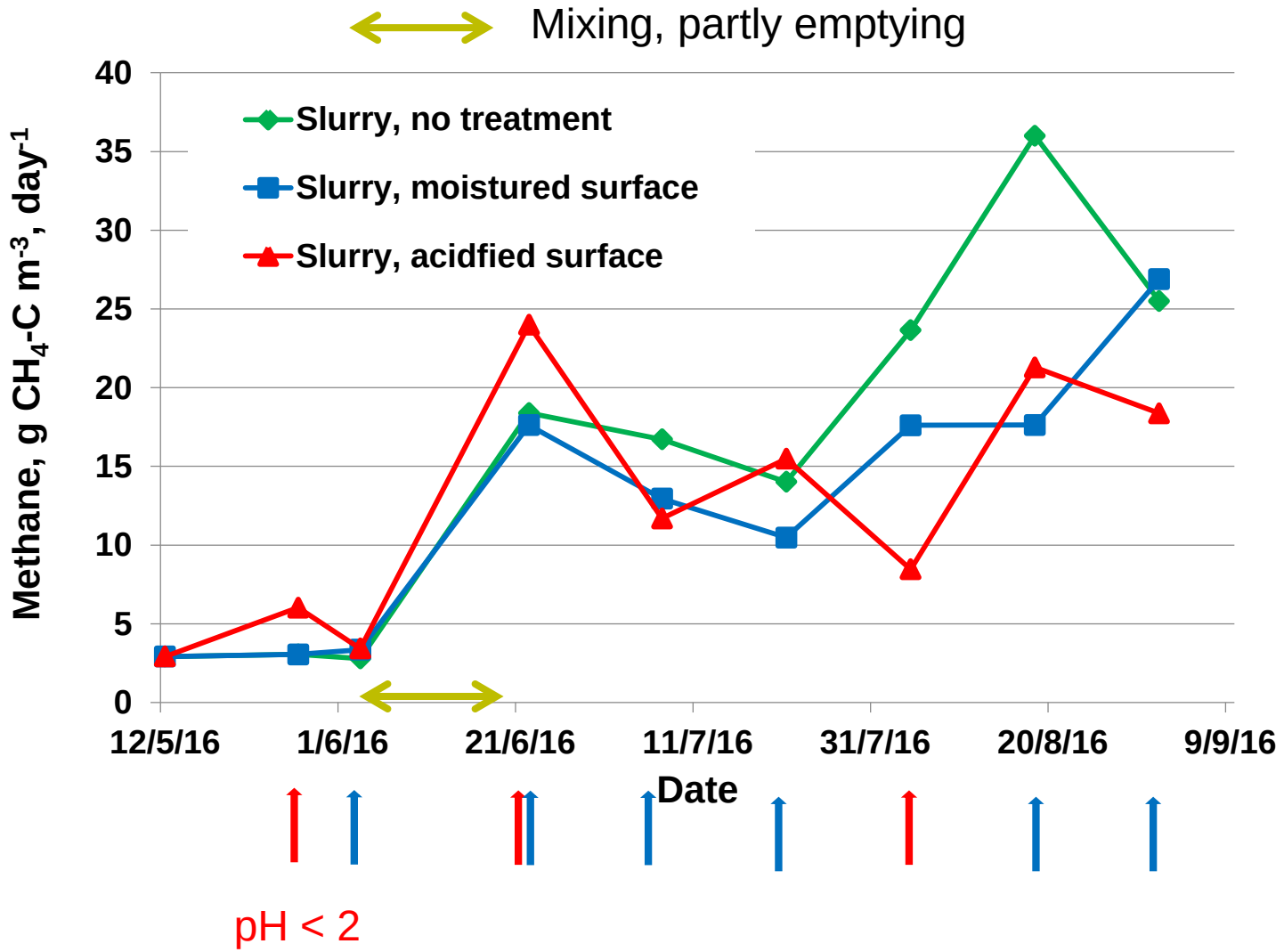
Total addition of water in treatment B: 24 Litre/frame = 44 mm rain.
Total addition of sulphuric acid (96%) in treatment C (pH< 2): 5.7 Litre/frame.

Temperature in storage



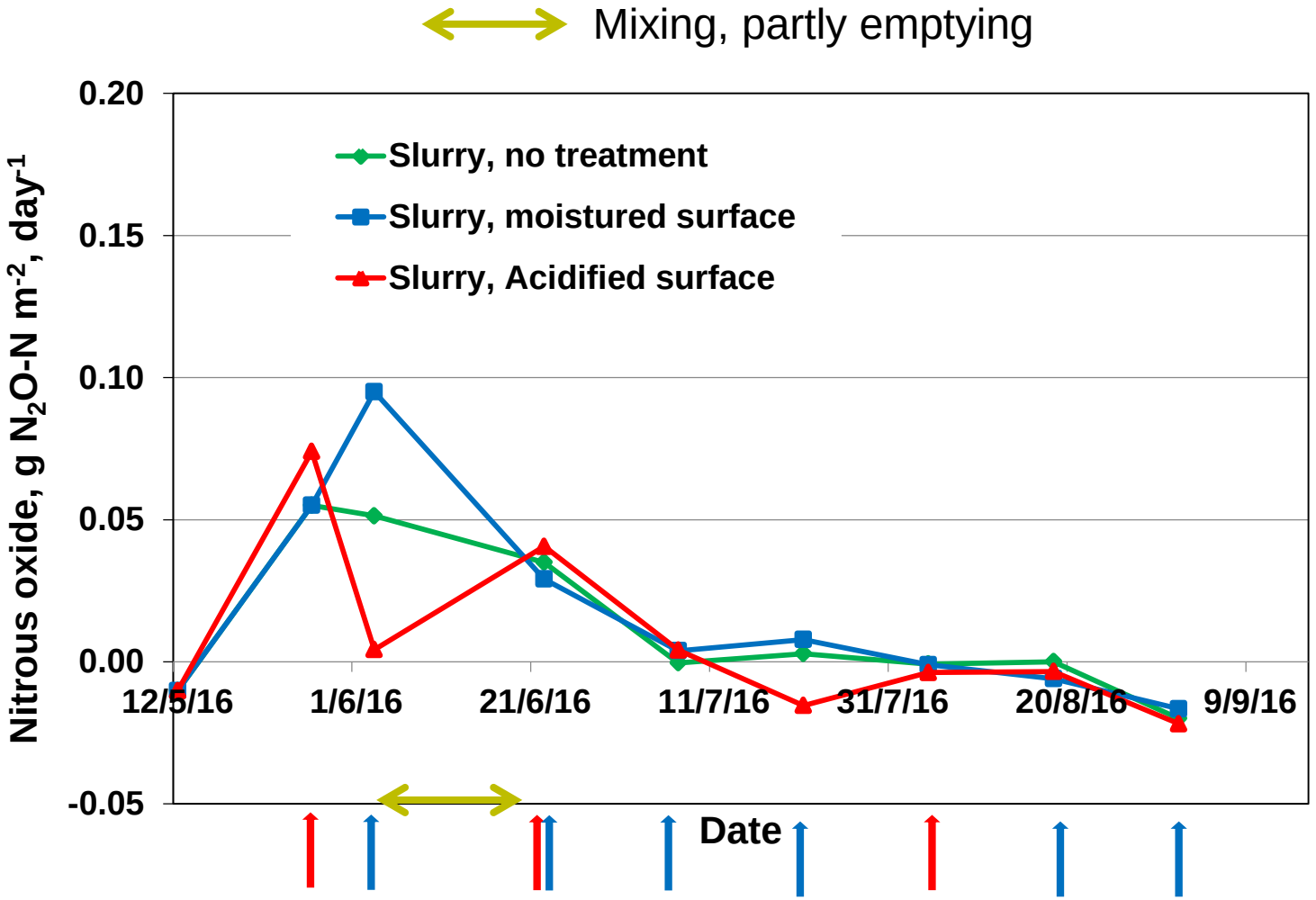
	Air temp., °C	Slurry temp., °C
Mean	15	15.5
Max	29.5	23.5
Min	-0.1	7.0

Results: methane



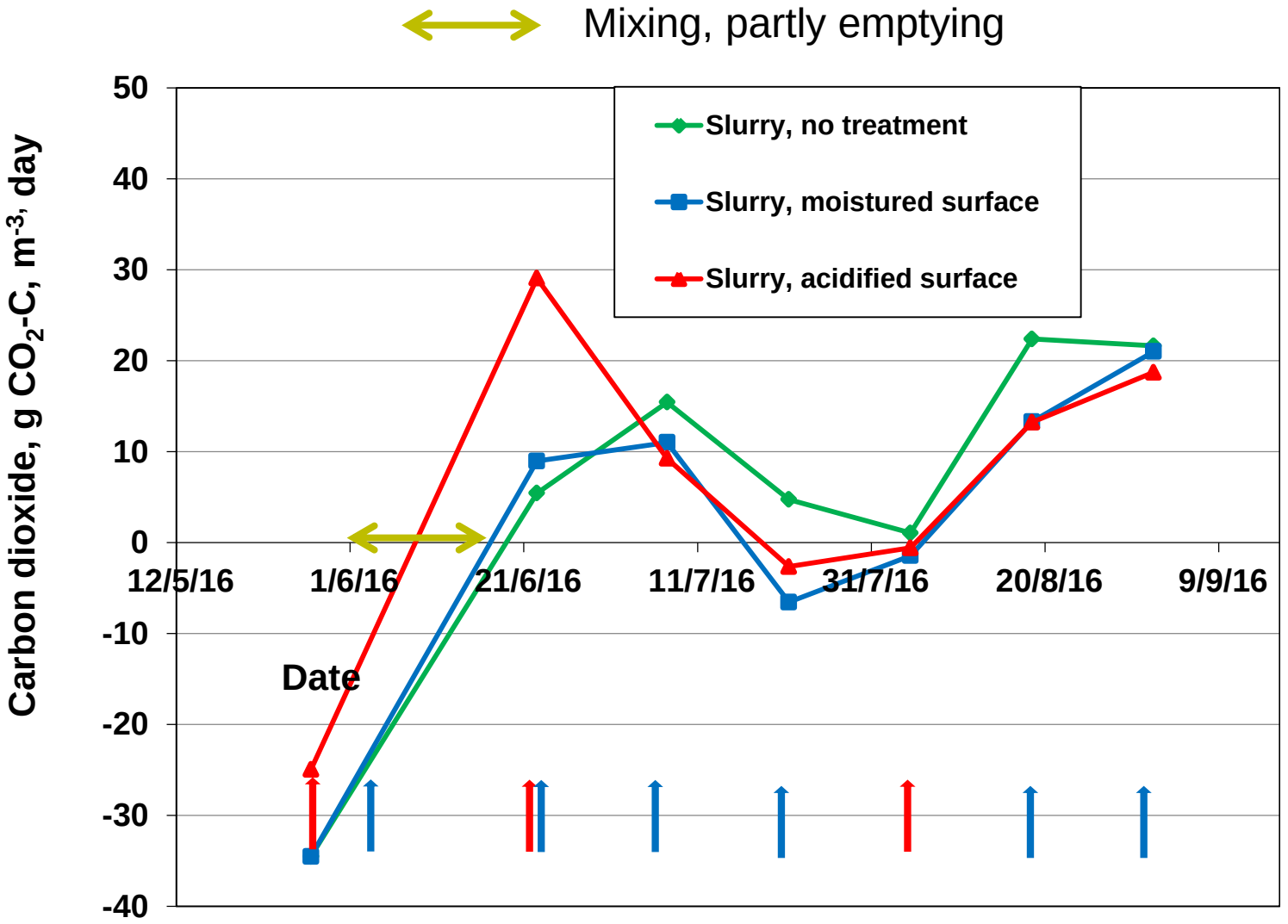
CH_4

Results: nitrous oxide



N_2O

Results: carbon dioxide



CO_2

Results: cumulative losses

				GWP_{100}, kg CO_2ekv. m^{-3}		
Treatment	kg CH_4-C m^{-3}	g CO_2-C m^{-3}	g N_2O-N m^{-3}	CH_4	N_2O	Sum CH_4 and N_2O
A. Control	1.86	397.4[a]	1.28	61.9	0.000	61.9
B. Water	1.41	-1.0[a]	1.49	47.1	0.000	47.1
C. Acid	1.47	1322[b]	1.00	49.0	0.000	49.0
PSE*	0.39	302.5		12.3		12.3
	ns	*	ns	ns	ns	ns

[a, b, c] Means with different letters within each column are significantly different (p<0.05),
*PSE, Pooled standard error

Discussions

- Working in full-scale is like some gambling, but still this is the reality!
- Others experiences/validations from measurements with dynamic chambers in full-scale would be valuable.
- Studies in crust properties has been studied in Denmark, but otherwise the knowledge are limited.
- Frames are less suitable in crust, as it created cracks like "chimneys for gases".

Conclusions

- Short-chop straw used in-house formed a smooth crust over stored slurry, giving low N_2O emissions during April-September.
- Crust treatment with water or acid did not decrease N_2O or CH_4 emissions, but acid treatment increased CO_2 emissions.
- Crust properties in full-scale are further interesting to study.
- The chamber technique gave higher CH_4 fluxes compared to earlier Swedish data. It seems not suitable for thicker crusts as the frames create cracks, giving “chimneys for gases”.

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THANK YOU

Lena Rodhe

Lena.rodhe@ri.se

+46 (0)105166951;
+46(0)761031333 (mobile)

Research Institutes of Sweden

Agrifood and Bioscience