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Baltic Slurry Acidification

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Ammonia emissions from storage

- non-digested and digested cattle slurry, with and without acid

Lena Rodhe, Johnny Ascue, Marianne Tersmeden and Leticia Pizzul

EU STRATEGY FOR THE BALTIC SEA REGION
FLAGSHIP

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Preface

Baltic Slurry Acidification is a flagship project in the action plan for EU strategy for the Baltic Sea Region (BSR). The project is being carried out between 2016-2019 with a budget of 5.2 million euros, of which 4 million euros is funded by the EU Regional Development Fund through the Interreg Baltic Sea Region Program.

The general aims of the project are to reduce ammonia emissions from animal production and create a more competitive and sustainable farming sector by promoting the implementation of slurry acidification techniques (SATs) throughout the Baltic Sea Region. This report falls under Work Package 2 – Technical feasibility studies, which aims to identify technical issues, bottlenecks and other barriers to the implementation of SATs, originally developed in Denmark, to other countries in the BSR.

This report is from Activity 2.6 ‘Ammonia emissions from acidified slurry’ but also includes parts related to Activity 2.3 ‘Slurry buffering capacity’. The work has been carried out by Partner RISE in Sweden. Senior Researcher Lena Rodhe led the work and has written the report. The experiment was conducted by a team consisting of laboratory engineer Johnny Ascue, technician Marianne Tersmeden and researcher Leticia Pizzul.

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Erik Sindhöj
Project Coordinator for Baltic Slurry Acidification

Summary

The study concerns acidification at the beginning of storage to reduce ammonia emissions during storage. The aim of the study was to evaluate the reduction of ammonia emissions by the acidification of cattle slurry, digested and non-digested, in storage under summer conditions.

Cattle slurry (CS) and digested cattle slurry (DCS) were taken from a dairy farm with a digester plant. The sulphuric acid required for acidification to pH 5.5 was determined by titration before the pilot-scale experiment began. In the pilot-scale experiment, each slurry type was divided into two containers. One batch was acidified to pH<5.5 by adding sulphuric acid (96%) slowly with gentle mixing. The other batch was not acidified. During acidification, the pH was measured frequently and the total amounts of acid added were noted. Temperatures were measured during the four-month storage period with loggers at 0.1 m from the bottom and 0.1 m from the surface of each container. Data were continuously recorded hourly.

Ammonia emissions were measured using a micrometeorological mass balance method with passive flux samplers. There were five measuring periods during the warm storage period from May to August. The length of the measuring periods ranged from 3 to 14 days, with the shortest period at the start of storage.

On a pilot scale, the acid consumption for reaching pH< 5.5 was 1.1 L/m^3 for CS and 6.2 L/m^3 for DCS. The change in pH after acidification was rather limited and the pH stayed <6 throughout the four-month storage period for both CS and DCS. On a laboratory scale, more acid was needed to reach pH 5.5, and the pH increased more, with less buffering, than on a pilot scale. The reasons for this could be higher temperatures, frequent mixing, small volumes, and the use of diluted acid on a laboratory scale compared with on a pilot scale. On a laboratory scale, it was possible to show differences in acid demand between slurry types, but the amounts of acid needed seem to be different (higher) compared with pilot scale.

The estimated cumulative NH_3-N emissions corresponded to about 19% of total-N for CS and about 26% of total-N for DCS. The estimated cumulative NH_3-N emissions were about the same as a percentage of TAN for CS and for DCS (57.8 and 53.9% respectively).

Emissions from the acidified batches of slurry were overall negligibly low. The addition of acid decreased ammonia emissions very effectively, for both CS and DCS.

Introduction

The study concerns acidification at the beginning of storage to reduce ammonia emissions during storage. In Denmark, the in-storage SAT on the market is usually used just before spreading (Rodhe et al., 2018) to achieve a reduction in ammonia (NH_3) emissions in the field after spreading.

In the literature there are small pilot-scale studies of ammonia emissions reduction during storage of pig slurry (Petersen et al., 2014) and cattle slurry (Misselbrook et al., 2016). In both studies the aim was to reach pH 5.5 at the start of storage. For pig slurry, the amount of acid used was 5.7 L/m^3 for reduction to pH 5.6 (Petersen et al., 2014) and 3.0 L/m^3, the latter only reducing the pH to 6.6 (Petersen et al., 2014). For the higher amount of acid, the ammonia reduction was 84% compared with no acid addition, while the smaller amount reduced the ammonia by half. Furthermore, the acid addition was very effective in reducing methane emissions by more than 90% during storage (Petersen et al., 2014).

The studies in the United Kingdom were performed during three seasons: cool, temperate and warm, with mean air temperatures of 7.3, 11.0 and 17.2 °C, respectively (Misselbrook et al., 2016). For CS, the amounts of acid added for the three seasons were 2.25, 4.5 and 3.15 L/m^3, respectively. The reductions in ammonia emissions were 56% in cold, 99% in temperate and 68% in warm conditions. As an average for all three temperatures and all individual measurements, CH_4 emissions were reduced by 61% and NH_3 by 75% when the slurry was acidified according to Misselbrook et al. (2016). Attachment 1 presents more details from the experiments.

The aim of the study was to evaluate the reduction of ammonia emissions by the acidification of cattle slurry and digested cattle slurry during storage under summer conditions.

Materials and methods

Ammonia emissions from stored slurry were studied on a pilot scale under summer conditions in 2017. This scale situated close to Uppsala, Sweden, involved containers of 2.9 m^3 (Karlsson, 1996) filled with about 2.0 m^3 slurry. The treatments are shown in Table 1.

Table 1. Treatments during pilot-scale storage

Treatment	Slurry types	Acids	pH
A	Cattle slurry (CS)	No acid	
B	Digested cattle slurry (DCS)	No acid	
C	CS	Sulphuric acid	<5.5
D	DCS	Sulphuric acid	<5.5

Slurry, buffering capacity and acid consumption

The slurry was taken from a dairy farm with a digester plant. The substrate consisted of cattle slurry with 0.5% by weight of crushed oats. The CS was collected at the exit from the cattle house and the DCS from the outlet of the digester. The digestion temperature was 36-37 °C and the hydraulic retention time (HRT) was about 37 days.

Laboratory titration

About three weeks before the slurry was collected for pilot-scale storage, smaller amounts were collected for titration to establish how much acid was needed to reach pH 5.5 for the two different kinds of slurry: CS and DCS. Briefly, small known volumes of concentrated sulphuric acid (96%) were added to the slurry sample with constant stirring at room temperature. The pH value after each addition was recorded. Swedish samples were titrated with 1N sulphuric acid, corresponding to a dilution of 1:19 (concentrated acid:water) (Pizzul et al., 2018). The amount of acid added to each sample was expressed in litres (L) of concentrated acid per m^3 of slurry.

Pilot-scale storage

The slurry was collected on 4 May 2017 and transported to the pilot containers, which were filled the same evening. The containers were filled to a depth of 0.7 m, corresponding to a volume of 2 m^3. At that point, the two slurry types were sampled by taking several subsamples for subsequent analysis for nutrient content including sulphur.

Each slurry type was put in two containers. One batch was acidified to $pH<5.5$ by slowly adding sulphuric acid (96%), with gentle mixing. The other batch was not acidified. During the acidification process, the pH was measured frequently with an instrument from Hanna Instruments Edge blue Serial No. C0211905E until the pH was stabilized < 5.5. A sensor in a plastic cover was used (Electrode pH-HALO Bluetooth(R) Plastic (Serial No. C4AD79). The total amounts of acid added were noted. Two temperature loggers (Tiny Tag Aquatic TG-4100, Intab Interface-Teknik AB, Stenkullen, Sweden) were placed in each of the containers to continuously record slurry temperature hourly at 0.1 m from the bottom and 0.1 m from the surface during the experiments.

The slurry batches were stored till 30 August 2017. No stirring occurred during this storage period.

Figure 1. Mixing and addition of sulphuric acid in the storage of DCS (on right). The extensive foaming had to be allowed to settle before more acid was added.

The randomized placement of the treatments is shown in Figure 2.

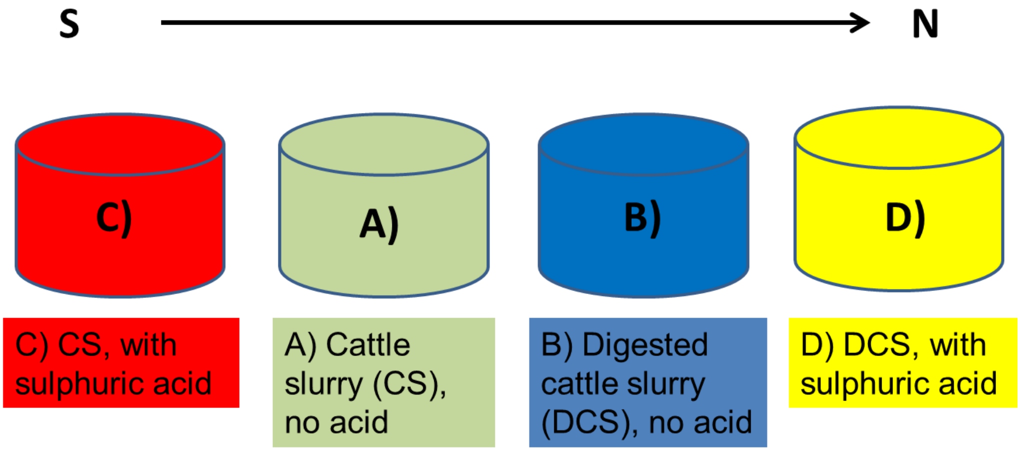

Figure 2. Randomized placement of the four different treatments, with the prevailing wind from the west.

Measurements of ammonia emissions

Ammonia emissions were measured using a micrometeorological mass balance method, described by Schjörring et al. (1992) and applied by Rodhe & Karlsson (2002). There were five measuring periods during the warm storage period from May to August. The length of the measuring periods ranged from 3 to 14 days, with the shortest at the start of storage. Figure 7 shows when the measuring periods occurred during the storage period.

Masts with passive flux samplers were placed round each container to the north, south, west and east (Figure 3). At the start of each measuring period, duplicate of passive flux samplers were attached at four heights on each mast (Figure 4): 0.46, 1.84, 4.6 and 8.0 m above the ground surface.

Figure 3. Experimental set up with containers and masts for ammonia measurements with passive flux samplers.

Weather data were taken from a nearby meteorological station at Ultuna, with means recorded hourly during the experiments.

Figure 4. Start of exposure of flux samplers on the second measuring occasion on 18 May (left). Close-up of flux samplers with inlet exposed to the source of ammonia (the slurry) and to the background (surrounding area) (right).

Data analysis

The exposed flux samplers were analysed in the laboratory at RISE JoL in Uppsala. The concentration data were transferred to a spreadsheet for calculating the ammonia emissions for the exposure times. The emissions between measurements were estimated by trapezoidal integration of individual sampling points. Total cumulative emissions of ammonia May-August were calculated by summarizing the measured and estimated emissions, and related to the original nitrogen contents of the slurry.

Results and discussion

Slurry properties

The properties of CS and DCS, without and with acid at the start and end of the storage period, are presented in Table 2. The starting analysis shows the typical decrease in TS from 9.0 to 5.5% by digestion, while in the same time the amount of NH_4-N had increased from 1.1 to 1.7 kg tonne^{-1}. Acidification increased the S content, and by the end of storage the concentration was about four times higher for the CS with acid compared with no acid, while the concentration for DCS with acid was about 17 times higher (4.6 kg tonne^{-1}).

Table 2. Properties of cattle slurry (CS) and digested cattle slurry (DCS), without and with acid at the start and end of storage, about four months later. The pH was analysed in fresh samples; other analyses were performed on samples that had been frozen previously

Slurry type	Time	TS, %	VS, % of TS	kg per tonne (wet basis)						pH[a]	Tot-C /Tot-N
				Tot-N	NH_4-N	P	K	S	Tot-C		
CS	Start	9.0	85.9	3.3	1.1	0.5	3.9	0.3	43.3	6.91	13.1
	End	10.4	83.6	3.4	1.5	0.51	5.04	0.32	50.8	6.37	14.9
CS, acid	Start[b]	-	-	-	-	-	-	-	-	5.51	-
	End	11.8	83.0	4.3	1.7	0.55	5.56	1.24	56.2	5.79	13.1
DCS	Start	5.5	79.3	3.3	1.6	0.4	3.6	0.2	24.8	8.05	7.5
	End	6.3	76.3	2.8	1.1	0.50	4.78	0.28	29.0	7.37	10.4
DCS, acid	Start[c]	-	-	-	-	-	-	-	-	5.35	-
	End	8.2	75.8	5.6	2.0	0.50	4.88	4.63	31.4	5.91	5.6

[a] Analysed on fresh sample.
[b] The same data as CS, except for increased sulphur (S) content because of acid addition.
[c] The same data as DCS, except for increased sulphur (S) content because of acid addition.

The starting volume in all containers was about 2.0 m^3, with slurry 0.7 m deep in each container. The depths and volumes of slurry with descriptions of crusts and any sedimentation at the end of storage are presented in Table 3. It shows that the volume decreased by 30-39% during the four-month storage period. Crust formation changed somewhat during the storage period. Figure 5 shows the surfaces after about two weeks of storage and Figure 6 about 2.5 months of storage, while Table 3 describes the crust at end of storage.

Table 3. Slurry depth, volume and occurrence of crust or sedimentation at the end of storage (30 August 2017) after nearly four months of storage

	End depth, m	Volume reduction, %	Crust	Bottom sediment
CS	0.43	39	No.	No.
DCS	0.47	33	Scattered pieces of crust all over surface, each about 0.01 m in diameter.	No.
CS, acid	0.49	30	No. Liquid layer on top.	No. Thicker slurry from 0.06 m below surface down to bottom.
DCS, acid	0.49	30	Yes, partial encrustation of surface, about 0.01 m thick.	No.

A) Cattle slurry (CS), no acid.

C) CS, with acid.

B) Digested cattle slurry (DCS), no acid.

D) DCS, with acid.

Figure 5. Photos of slurry surfaces for the four treatments taken on 18 May at 1 pm. CS and DCS had thin crusts. CS with acid had no crust, while a paper-thin layer was formed after the foam had settled (lower right) on the acidified DCS.

A) Cattle slurry (CS), no acid.

C) CS, with acid.

B) Digested cattle slurry (DCS), no acid.

D) DCS, with acid.

Figure 6. Photos of slurry surfaces for the four treatments taken on 21 July. The crust formation was about the same as two months earlier (Figure 5).

Storage conditions

The wind speed, total precipitation, and air temperatures as well as those of the slurry in the different containers are presented for the measuring period in Table 4. The summer 2017 was relatively cold with a mean air temperature of 14.0 °C throughout the measuring period (Table 4). The meteorological station was placed on Ultuna (59.82 °N lat., 17.65 °E long.). Air temperature was measured at 1.5 m above ground, and windspeed 10 m above ground. Recordings were made every minute, and daily mean values are presented here in the report.

Table 4. Air and slurry temperature (daily mean, max and min) during storage of cattle slurry (CS), and digested cattle slurry (DCS), without and with acid, respectively, during the measuring period from 5 May to 28 August

		Slurry temperature, °C					
	Air temperature, °C	A. CS	B. DCS	C. CS, acid	D. DCS, acid	Wind speed, m s^{-1}	Total precipitation, mm
Mean	14.0	16.6	15.8	14.0	15.8	2.6	126
Max	20.5	22.2	19.5	17.0	23.3	4.7	-
Min	-0.1	8.6	8.1	6.9	9.5	1.1	-

Figure 7 presents the air and slurry temperature during the season, with the five occasions of ammonia measurements marked with blue arrows. During the first measurement period for ammonia (5-8 May), the temperature was very low, and some wet snow also fell. During the second measurement period, the temperature had increased somewhat, and it rose even more on the last three occasions.

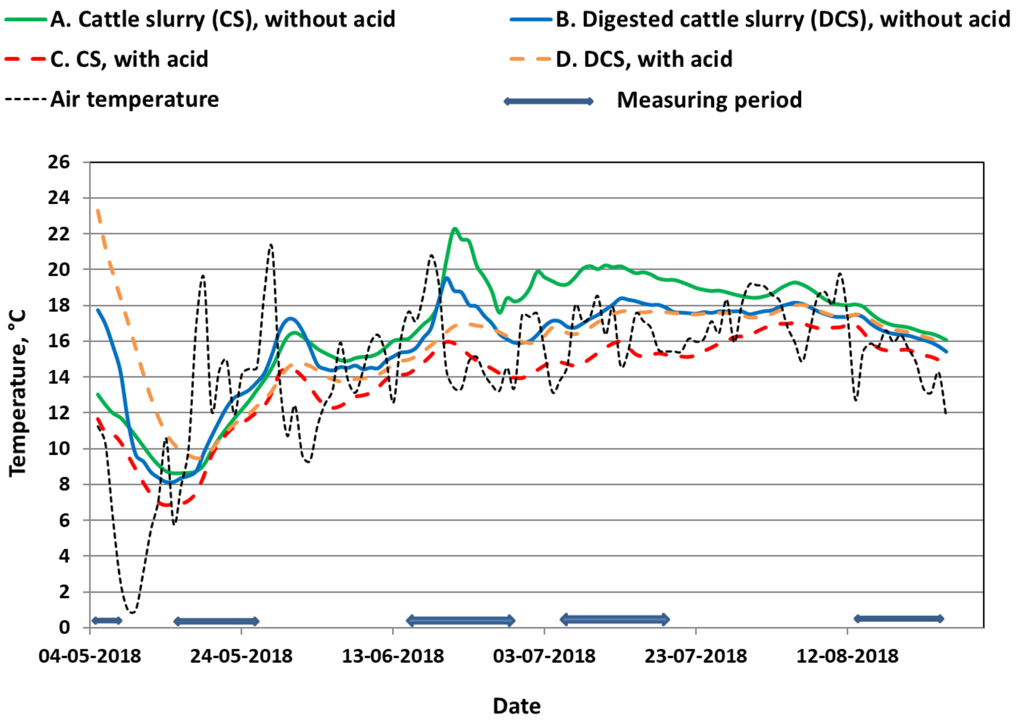

Figure 7. Daily mean temperature in slurry and air during storage measuring period 5 May-28 August 2017.

At the start, the temperature of the DCS was higher compared with the non-digested CS, but the two temperatures equalized within two weeks (Figure 7). The DCS acidified with 6.2 L/m^3 of sulphuric acid had a higher temperature (23.5 °C) after acidification, compared with about 18 °C for the non-acidified DCS. For CS with small amounts of acid added, the temperature difference was small (about 2 °C), in this case the acidified slurry being cooler. During the season the temperature varied between the treatments, perhaps because of slurry surface properties, solar radiation, the sensor height in the slurry and the placement of containers. However, the slurry temperatures in the most northerly (DCS with acid) and the most southerly (CS with acid) containers were about similar. The sensor in CS showed the highest temperatures in summer, and much higher than in the acidified CS. The sensor may have risen a little nearer to the slurry surface in the containers with CS.

Acid consumption and buffering capacity

Laboratory titration

The pH values at the start were 6.8 for CS and 8.1 for DCS (Figure 8), about the same as three weeks later when the pilot-scale containers were filled (Table 2). The pH decrease was faster for CS compared with DCS, which showed a high buffering capacity (Figure 8). The amount of acid required was about three times higher for DCS (about 9 L/m^3), compared with CS (2.5 L/m^3) to reach pH 5.5. The higher buffer capacity of DCS may be due to a higher concentration of bicarbonate, lower content of volatile fatty acids and higher concentration of ammonium nitrogen in comparison to CS.

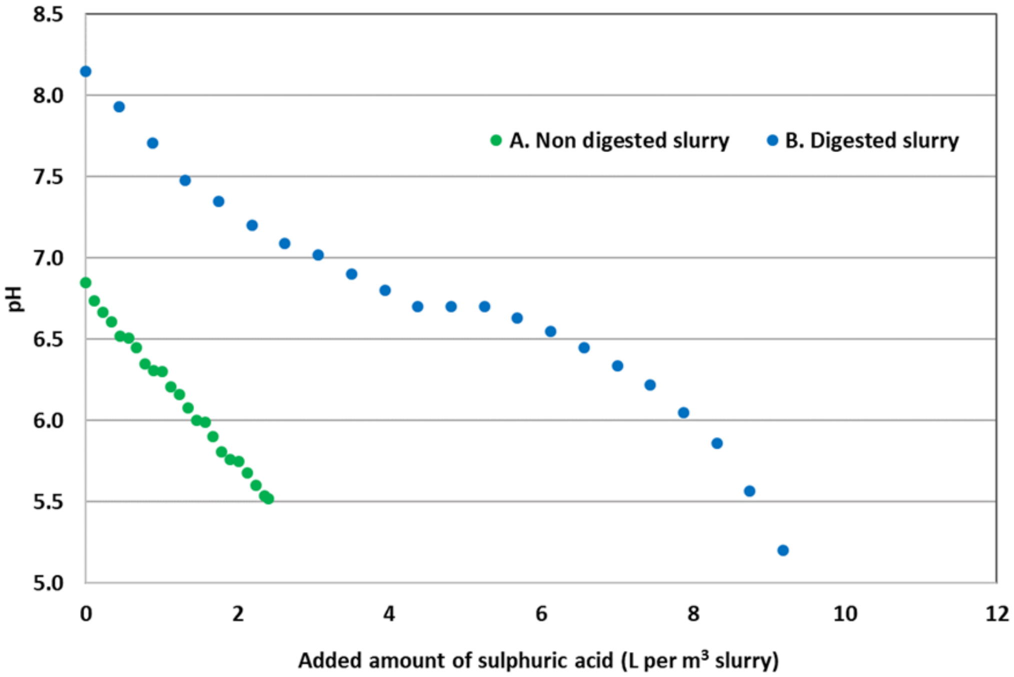

Figure 8. Example of titration curves for CS and DCS to pH 5.5 by stepwise addition of diluted sulphuric acid, presented as the amount of concentrated acid. The slurry was from the same farm as for the pilot-scale study but was collected about three weeks before that used in the pilot-scale storage.

Pilot-scale storage

The acid consumption for achieving pH<5.5 at the start of storage was only 1.1 L/m^3 for CS and 6.2 L/m^3 for DCS. Other pilot-scale studies show at least twice as much acid is required for non-digested slurry (Petersen et al., 2014; Misselbrook et al., 2016) (Appendix 1). On the other hand, the DCS needed much more acid to reach the target pH of 5.5. A higher pH at the start is one reason; another could be the increased content of ammonium nitrogen (NH_4-N) because of digestion.

The initial pH was 6.9 for CS and 8.1 for DCS, measured in well-mixed slurry. After nearly four months of storage, the pH in CS had fallen to 6.4 and in DCS to 7.4 (Figure 9). After acidification of CS and DCS, the pH increased during the nearly four-month storage period, but the increases was moderate for both CS and DCS, with a final pH<6 (Figure 9; Table 2).

Between the starting and ending pH measurements, the pH was measured several times at the top of the undisturbed slurry in storage (Figure 9). The pH from those measurements in acidified CS and DCS was slightly higher than in the mixed slurry at the end of storage, perhaps because the acid, having a high density (1.6 tonne/m^3), was more concentrated in the bottom layer and less so in the top of the slurry when not well-mixed.

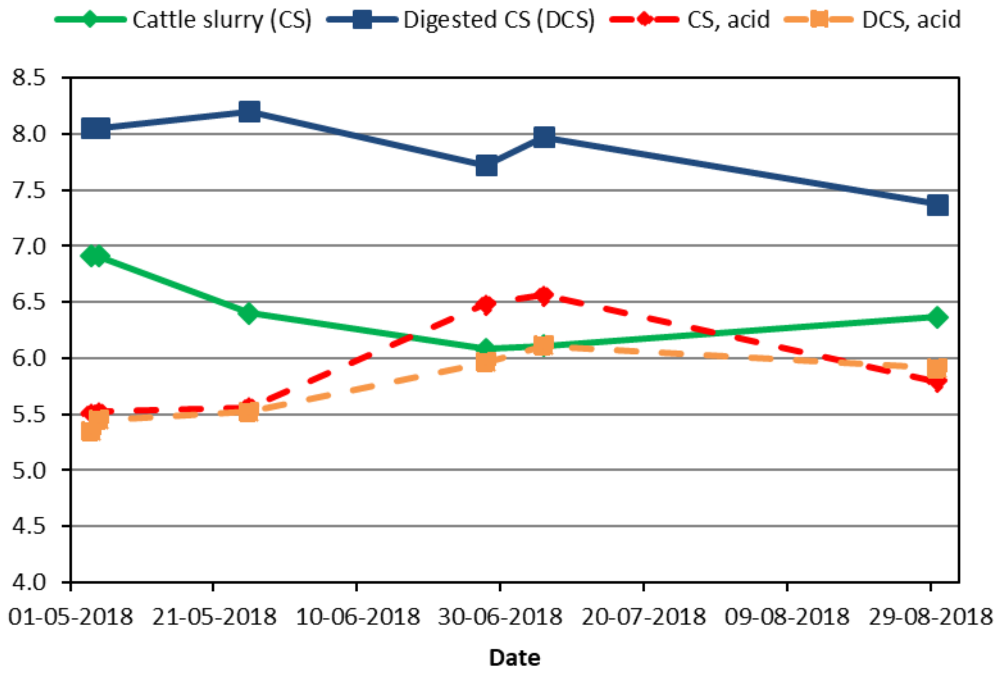

Figure 9. Measured pH during storage from 4 May-30 August 2017. On the first and last occasions, the measurements were made in well-mixed slurry, while the intermediate measurements were made in undisturbed slurry about 0.05-0.10 m below the surface (not representative of the whole batch of slurry).

At the end of storage, pH was measured before and after mixing (Figure 10). The pH in the top layer of the unmixed slurry was higher than when the slurry had been mixed. In this pilot-scale storage, the pH stabilized once mixing began.

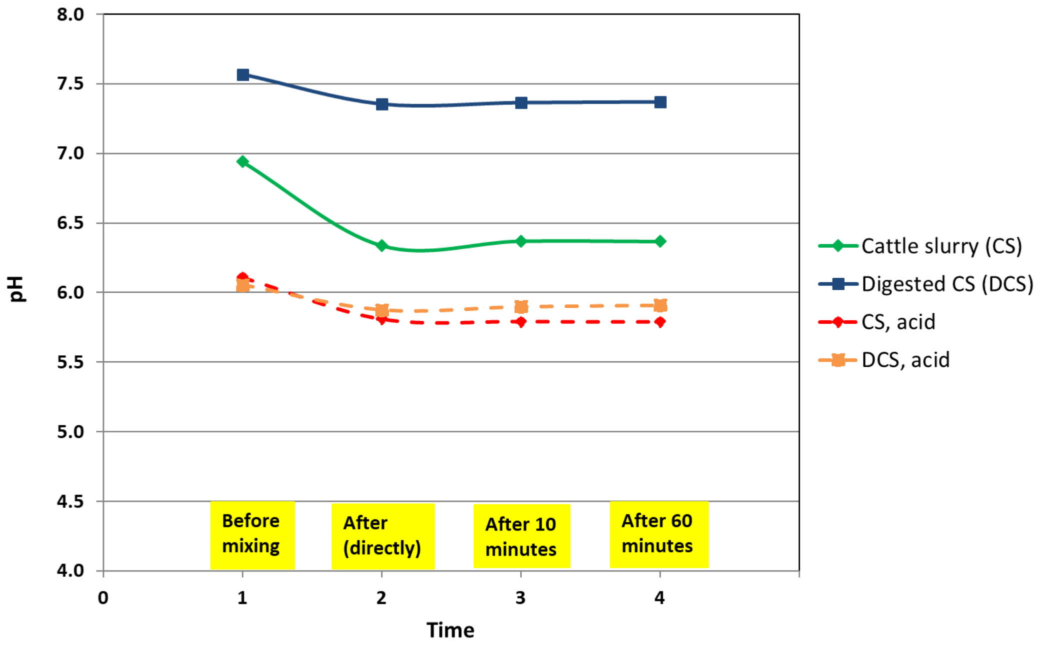

Figure 10. Measured pH just below the surface in the different slurry treatments, at the end of storage (30 August) at different times: just before mixing and at different times after mixing.

Comparison of laboratory and pilot scales

On a laboratory scale the amounts of acid needed in the titration of CS and DCS were much higher at 2.5 and 9 L/m^3, respectively (Figure 8) than in the pilot scale (1.1 and 6.2 L/m^3, respectively).

A parallel laboratory study showed that when acidifying down to pH 5.5, total solids (TS), total nitrogen (Tot-N) and volatile solids (VS) were relevant factors for predicting acid consumption (Joublin, 2017). The studies of Joublin (2017) were performed on a small scale in a laboratory at about 20 °C, with repeated intensive mixing. Conditions were therefore very different from those of the undisturbed slurry in outdoor storage (mean temperature about 14-16 °C, Table 4). In another laboratory-scale study, in most cases 6-8 L/m^3 of acid was needed for CS (Pizzul et al., 2018) to reach pH<5.5. However, this was with weekly mixing and the addition of acid over a two-month period. Another difference between the pilot- and laboratory-scale studies was that on a pilot scale the acid was not diluted, while on a laboratory scale it was diluted 1:19 (concentrated acid:water) to avoid foaming and rapid temperature rise.

Ammonia emissions

Ammonia samplers were exposed on five occasions during the storage period (Figures 7 and 11).

In Figure 11, the measured emissions on those occasions are marked with solid lines, and estimated emissions with dotted lines. The ammonia fluxes from each container were rather low because of the small quantities of slurry together with rather low NH_4-N concentrations. The emissions were especially low on the first measuring occasion, when the air temperature was low. Presumably, a longer exposure time for the samplers would have increased the accuracy of the flux measurements. The negative flux values might be explained by the small amounts of ammonia captured by the flux samplers, meaning that the differences between the source and background levels were within the error range. When the flux is calculated, small concentration differences between samplers could therefore lead to negative fluxes.

Ammonia emissions occurred throughout the storage period for the non-acidified slurries. For CS, the emissions were highest on the last measuring occasion, while the emissions from DCS seemed to decline at that time, perhaps because of previously higher emissions.

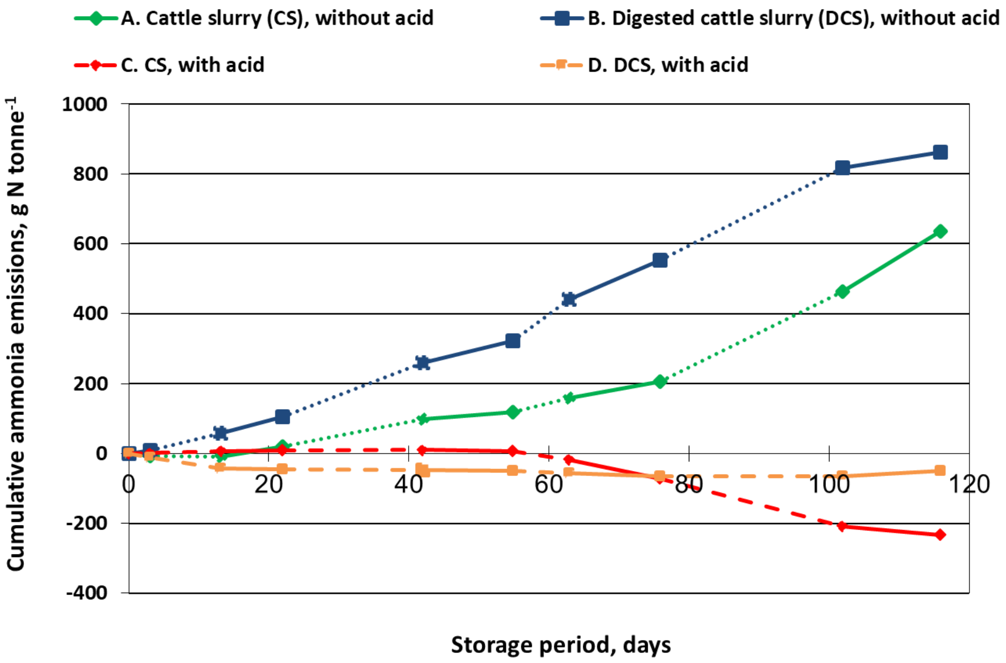

Figure 11. Cumulative ammonia emissions from CS and DCS, without and with acidification to pH 5.5 over four months of storage. The cumulative emissions are based on measured emissions (solid lines) and estimated emissions (dotted lines).

Both CS and DCS had a content of 3.3 kg N tonne^{-1} (Table 2). The estimated cumulative NH_3-N emissions corresponded to about 19% of total-N for CS and about 26% of total-N for the DCS (Table 5).Acidification resulted in a large reduction in NH_3 emissions, because NH_3 emissions were negligible for both CS and DCS with acids. This means acidification was a very effective mitigation method for NH_3 emissions from stored slurry.

The NH_3-N emissions were about the same as a percentage of total ammoniacal nitrogen (TAN), for CS as for DCS (57.8 and 53.9%, respectively). The default value for ammonia emissions from cattle slurry is an average of 6% of total-N on an annual basis (Karlsson & Rodhe, 2002). The default values are based on full-scale storage with a natural stable covering crust. In this case, the study was carried out during the warmest period of the year, when the highest emissions are occurring, which means a higher loss than the annual mean could be expected. Furthermore, as can be seen in Figures 5 and 6, no crust that could inhibit ammonia emissions was formed.

Table 5. Cumulative NH_3-N emissions from the four treatments presented as estimated cumulative emissions in g N tonne^{-1}, % of total N and % of TAN content at the start

Treatment	Estimated cumulative emissions, g N tonne^{-1} slurry	NH_3-N emissions, % of Total-N	NH_3-N emissions, % of TAN
A. CS	636	19.3	57.8
B. DCS	862	26.1	53.9
C. CS, acid	-234	-7.1	-21.2
D. DCS, acid	-50	-1.5	-3.1

In other studies, the reductions in ammonia emissions have been large for acidified slurry in storage compared with non-acidified slurry (Appendix 1). Misselbrook et al. (2016) showed that acidification of cattle slurry achieved a reduction of 56% in the cool season, 99% in the temperate season and 68% in the warm season compared with no acidification (Appendix 1a). In two types of pig slurry, acidification reduced the ammonia emissions by 84% when acidified with 5.7 L/m^3, and by 49% with 3.3 L/m^3, respectively (Petersen et al., 2014) (Appendix 1b).

Conclusions

- On a pilot scale, the amount of acid needed to achieve pH<5.5 was 1.1 L/m^3 for cattle slurry (CS) and 6.2 L/m^3 for digested cattle slurry (DCS).
- On a pilot scale, the change in pH after acidification was rather limited. The pH stayed <6 throughout the four-month storage period.
- On a laboratory scale, more acid was needed to achieve pH 5.5 and the pH increased more, with less buffering, than on a pilot scale. The reasons for this could be higher temperatures, frequent mixing, small volumes, and the use of diluted acid on a laboratory scale compared with pilot scale.
- The laboratory scale showed differences in acid demand between slurry types, but the amounts of acid needed seem to be different, because they were higher compared with pilot scale.
- The estimated cumulative NH_3-N emissions corresponded to about 19% of total-N for CS and about 26% of total-N for DC.
- The estimated cumulative NH_3-N emissions were about the same as a percentage of TAN for CS and for DCS, at 57.8 and 53.9%, respectively.
- The emissions from the acidified batches of slurry were very low, and overall negligible.
- The addition of acid decreased ammonia emissions very effectively, for both CS and DCS.

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Appendix 1a. Data from pilot-scale studies, cattle slurry

Acidification at start of storage (effect during storage)

Results from the United Kingdom on the effect of acidification on ammonia and methane emissions ***during storage*** *of different slurry types in pilot-scale storage. The studies were performed during* ***three different seasons****, cool, temperate and warm, with mean air temperatures of 7.3, 11.0 and 17.2 °C, respectively. Misselbrook et al., 2016*

Slurry type	Amount of acid added	Duration of study, days	Age of slurry at start	pH start	pH end	NH_3 emissions, g N m^{-3}	Reduc-tion NH_3, %	Reduc-tion CH_4, %
	Pilot scale, storage volume 1.1 m^3							
1a. Cattle slurry, stored cool (CS_C).	2.5 L/tank, ~0.9 m^3 per tank= ~2.25 L/m^3	70 (Dec.-Feb.)	Slurry pit, 1 week?	5.5	Not given	46	56*	84*
1b. CS_C, Control.	No acid, Control		Slurry pit, 1 week?	7.3	Not given	104		
2a. Cattle slurry, stored temperate (CS_T).	5 L/tank= 4.5 L/m^3	70 (Sept.-Nov.)	Slurry pit, 1 week?	5.1	Not given	2	99*	90*
2b. CS_T, Control.	No acid, Control		Slurry pit, 1 week?	7.1	Not given	166		
3a. Cattle slurry, stored warm (CS_W).	3.5 L/tank= 3.15 L/m^3	61 (July-Sept.)	Slurry pit, 1 week?	5.7	Not given	102	68*	63*
3b. CS_W, Control.	No acid, Control		Slurry pit, 1 week?	7.3	Not given	321		

*Own calculation from cumulative losses.

Appendix 1b. Data from pilot-scale studies, pig slurry

Acidification at start of storage (effect during storage)

Results from Denmark on the effect of acidification on ammonia and methane emissions ***during storage*** *of different slurry types in pilot-scale storage. The studies were performed during the warm season. Petersen et al., 2014*

Slurry type	Acid added	Length of storage, days	Age of slurry	pH start	pH end	NH_3 emissions, g N m^{-2}	Reduc-tion NH_3, %	Reduc-tion CH_4, %
			Pilot scale, storage volume 6.5 m^3					
1a. Pig slurry, finishers	10-11 kg/tonne= 5.7 L/m^3, In-house	83 (19 May-10 Aug.)	1 months	5.6	No info	112	84	99 (>90)
1b. Pig slurry, finishers	No acid, Control	83	1 months	7.8	No info	715.9		
2a. Pig slurry, finishers	6 kg /tonne= 3.3 L/m^3, In-storage	83	Between Fresh and >6 months	6.6	No info	247	51	94 (>90)
2b. Pig slurry, finishers	No acid, Control	83	Between Fresh and >6 months	7.2	No info	507.8		

Interreg
Baltic Sea Region
Baltic Slurry Acidification

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

www.balticslurry.eu

Summary of the project

Baltic Slurry Acidification is an agro-environmental project financed by Interreg Baltic Sea Region under the priority area Natural resources and specific objective Clear Waters. The aim of the project is to reduce nitrogen losses from livestock production by promoting the use of slurry acidification techniques in the Baltic Sea Region and thus to mitigate eutrophication of the Baltic Sea. The Baltic Slurry Acidification project started in March 2016 and was finalised in February 2019.

Summary of the report

The aim of the study was to evaluate the reduction of ammonia emissions by the acidification of cattle slurry, digested and non-digested, in storage under summer conditions. In the pilot-scale experiment, each slurry type was divided into two containers. One batch was acidified to pH<5.5 by adding sulphuric acid slowly with gentle mixing.

Emissions from the acidified batches of slurry were overall negligibly low. The addition of acid decreased ammonia emissions very effectively, for both digested and non-digested cattle slurry.

Contributing partner

RI. SE
Research Institutes of Sweden