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A NEW METHOD FOR REDUCTION OF NH_3 EMISSIONS FROM PIG HOUSING SYSTEMS BY ADDING SULPHURIC ACID TO SLURRY

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Abstract

Effects of adding sulphuric acid to slurry by flushing the waste pits were studied in a commercial finishing unit with four identical sections. Each section included 300 pigs on fully slatted floors. Waste pits in two control sections had a pull-plug system installed for removal of slurry. The other two sections had a new developed and patented waste handling system using a sulphuric acid treatment.

In the new system the slurry was treated with sulphuric acid in a storage tank outside the building. At the bottom of the tank concentrated sulphuric acid was added at a ratio of approximately 5 kg per tons of slurry. This reduced the pH to about 5.5. Simultaneously slurry was aerated by injecting compressed air to prevent the sulphate-ion changing into noxious hydrogen sulphide. Slurry pits were flushed 6 times daily with sulphuric acid treated slurry.

Ammonia emission was measured continuously to evaluate emission rates from control and experimental sections. Odour emission was calculated from two point measurements per batch when pigs weighed 40, 60 and 80 kg. In addition data on performance and health of the pigs were collected. The technical performance of the new developed slurry system was evaluated as well.

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Measurements indicate that ammonia emission can be reduced by approximately 70%. At the same time field experiments shows a much higher utilization of the nitrogen in the acid treated slurry compared with non-treated slurry.

The technical system

To prevent emission of ammonia into the atmosphere from pig production facilities, a simple technical procedure was invented in which the ammonia was trapped in the form of ammonium, keeping the nitrogen in the slurry pit. By adding sulfuric acid into sprinkling water and ultimately the swine slurry, the pH is lowered to 5.5, keeping the ammonia in the swine slurry as ammonium. Recirculating it through a drainage pump and oxygen injector system also oxidizes the slurry.

The slurry treatment system is in two parts. First, the slurry is collected under the slots in a collection channel. The channel transfers the slurry to a slurry pit. A mixture of water and sulfuric acid (pH = 5.5) is sprayed from the ceiling of the building. Slurry in the slurry pit is recirculated with a drainage pump to mix it uniformly. Sulfuric acid and oxygen are added to the slurry in the recirculation process. To reach a pH level of 5.5 in the swine slurry, a pH monitor is placed in the slurry and connected to a sulfuric acid dose pump. The system is automatically controlled. Therefore every parameter can be varied freely.

The chemical reactions

The normal reaction that happens in the swine slurry inside the slurry pit at pH 7 is:

$$CO(NH_2)_2 + H_2O \rightarrow NH_4+ + 2\ HCO_3 \rightarrow 2\ NH_3 + CO_2 + H_2O \qquad (1)$$

At pH 7, the following equilibrium exists:

$$NH_4+ \quad < > NH_3 + H+ \qquad (2)$$

By sprinkling the slotted area with fluid at pH 5.5, the urease producing bacteria were inhibited. In that way, reaction 1 was reduced. By lowering the pH to 5.5 in the slurry pit with sulfuric acid, a new reaction begins:

$$2\ NH_3 + H_2SO_4 \rightarrow 2\ NH_4^+ + SO4^{2-} \qquad (3)$$

In this way, the emission of ammonia was reduced. Depending on the amount of ammonia, an equivalent amount of sulfuric acid was added, keeping the ammonia as ammonium. Oxidizing was necessary for preventing hydrogen sulfide development.

Materials and methods

Effects of adding sulphuric acid to slurry followed by flushing of the waste pits were studied in a commercial finisher unit with four identical compartments. Each compartment included approx 300 pigs on fully slatted flooring. The layout of the test facility at the commercial finisher unit is shown in figure 1.

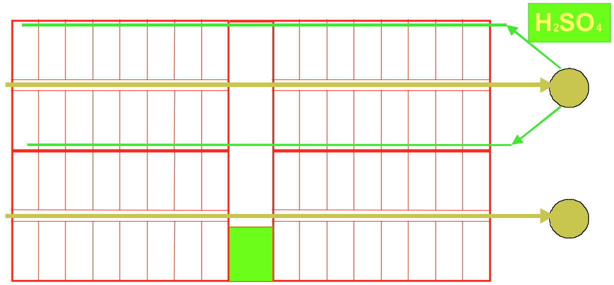


Figure 1. The layout of the test facility. Each compartment included 16 pens on fully slatted flooring. Waste pits in two compartments had a 315 mm pull-plug-system installed for removal of waste (control). The other two comprised a waste handling system with sulphuric acid treatment. In this system the treated slurry was pumped through 110 mm pipes from the small storage tank outside the building into the waste pits. Every waste pits in the two compartments were flushed at the same time.

Ammonia emissions were measured once every half hour to evaluate emission rate from control and experimental compartments. The measuring device is described in figure 2. The ventilation rate was calculated indirectly by measuring the concentration of carbon dioxide.

Odour emission was calculated from odour concentration measurements when the pigs weighed 40, 60 and 80 kg, respectively. The sample air for analysis was sampled over a period of about 40 minutes. Within 24 hours the odour samples were brought to a laboratory and analyzed according to the CEN-standard. In addition, data on performance and health of the pigs were collected.

Figure 2. The measuring device from Veng System for measuring ammonia emissions. We used a measuring device from Veng System. With this system, measurement of the concentration of ammonia and carbon dioxide was possible. The company Dräger provided the sensors. The device included a valve system that made it possible to switch between different compartments. In each of the four compartments at the exhaust pipe, a pump was placed pumping continuously a sample of air through the Teflon tubes to the measuring device. The fifth canal was the reference canal measuring the ambient concentration.

The technical performance of the system was evaluated by noting the technical failure that might occur. Working environment – especially the potential risk of hydrogen sulphide – was evaluated by point-measurements every two weeks. In addition, consumption of sulphuric acid and energy was measured as well. Statistical analysis was based on eight replicates where the statistical unit was one batch of finishing pigs from 30 to 100 kg. The analyses were carried out by a t-test.

The study is planned to end December 2003. Therefore at the time of writing, collection of data is still in progress.

Results and discussion

The odour measurements started in November 2002 when all the compartments were filled with a new batch of pigs. The batch of pigs starting august 2002 was also included in the ammonia measurements. The third batch of pigs started February 2003.

As shown in figure 3 and 4, the acidifying system has been efficient in reducing ammonia emissions.

Figure 3 Reduction of ammonia from August 5, to December 24, 2002. *On average the reduction was 73 and 75 percent between compartment 2 and 1, and compartment 3 and 4, respectively.*

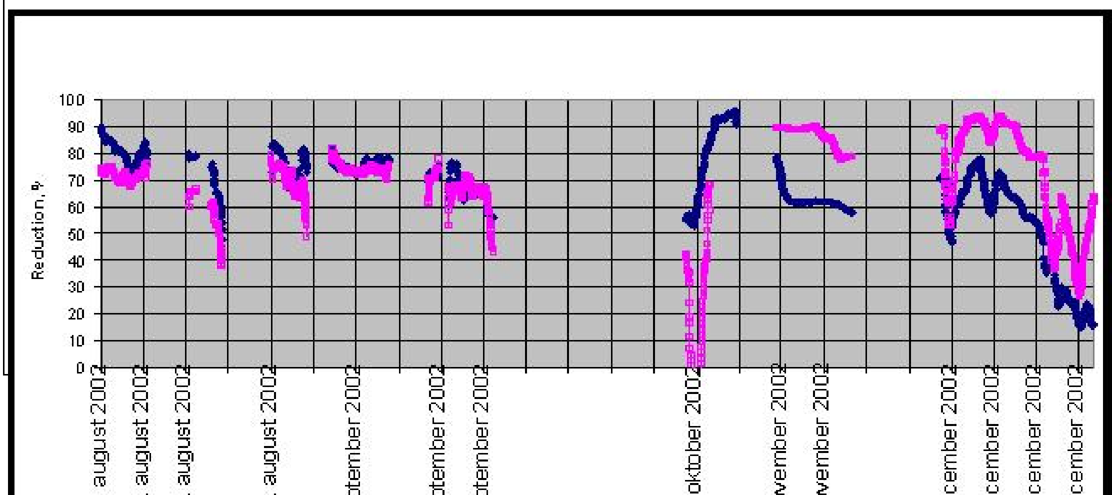
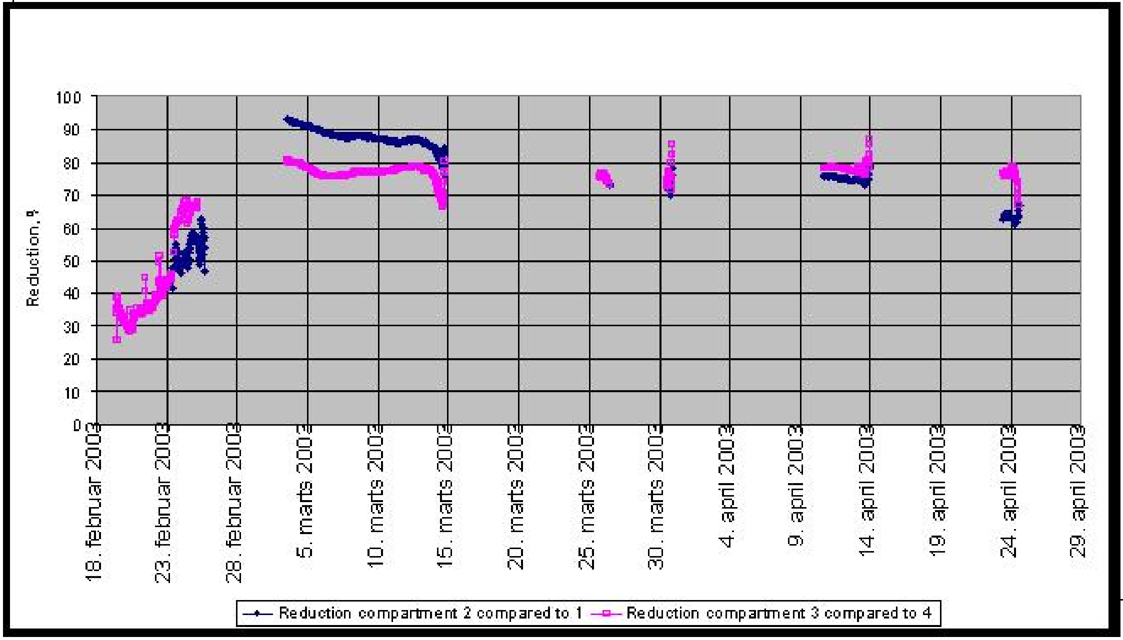


Figure 4. Reduction of ammonia from February 18, to April 24, 2003. *On average the reduction was 77 and 70 percent between compartment 2 and 1, and compartment 3 and 4, respectively. Data from the period 24th of December 2002 until 18th of February 2003 was omitted. In this period there was a breakdown in the acidifying and flushing system.*



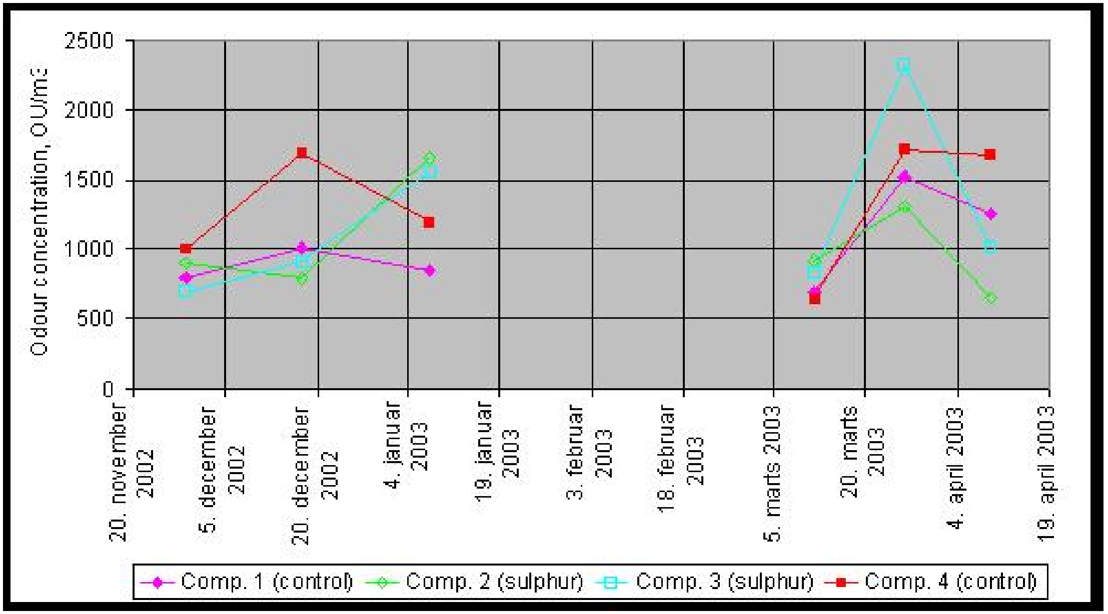
On average there has been a reduction of 70 and 77 percent between compartments with and without acidifying of slurry. From basic chemistry it was also expected that a pH-value about 5.5 would nearly eliminate ammonia emissions from waste pits. Therefore one of the preliminary conclusions is that the rest of the ammonia emissions – about 30 percent - must originate from fouled pigs, slatted flooring and pen equipment.

In general the flushing system was not able to create any "flushing" when the treated slurry was pumped into the waste pits. The relatively small 110 mm pipes and the fact that 16 waste pits were flushed at the same time reduced the flushing speed dramatically. The flushing system was more like a "filling system". From this experience the company have changed the flushing system in new built waste handling systems.

The odour measurements are shown in figure 5. There has been huge variability in the odour concentrations and it is not possible to evaluate whether this acidifying system does reduce or increase the odour emissions. If the acidifying system works perfect there might be a small reduction in odour emissions, but it is also clear that the system includes a potential risk of increased odour emissions, if the system breaks down. The system was broken down when the odour measurements were taken on the 7th of January 2003.

From an odour point of view it is important that the relatively high concentration of sulphur in the slurry is kept aerated all the time. Otherwise bacterial activity rapidly will reduce sulphur components into highly potent sulphur-containing odour components.

Figure 5. Measurements of odour concentration



The experience at the test facility was that the character of the odour differed between compartments with and without the slurry treatment system. Normally you would not be able recognize the specific smell of ammonia in the compartment with the treated slurry, because the concentration normally was below the odour threshold for ammonia at about 5 ppm. In the periods where the slurry treatment system was broken down there could be quite a "sulphur-like" smell in the compartments with treated slurry.

From the preliminary results it can be concluded that the newly developed acidifying system seems very efficient in reducing ammonia emissions on the circumstances that acidifying, aeration and flushing system works as prescribed. Unfortunately the system does not seem to have same potential for odour reduction. In case of break down there seem to be a significantly risk for increase in odour emissions.

Effects on pigs

Measuring the daily gains in the treated and control sections shows a slightly increase in the daily growth rate in the treated sections. At the time of writing, collection of data is still in progress. It seems that the increase in growth rate is not significant.

Effects on people

The reduction in ammonia concentrations between the treatment section and the control section gives a better working environment and a better health for the farmer and the staff members. In addition we have also seen a reduction in dust concentration in the treated sections.

A better fertilizer

From a fertilizer and plant nutrient point of view the system contains important features, which also are about to be evaluated. Preliminary results had shown that pH sustains at about 5.5 during the storage period and also when the slurry is applied to the plants. Therefore it seems possible to obtain a significant decrease in ammonia losses from animal production facilities with this newly developed acidifying system.

Increase of nitrogen

The analyses of the treated and untreated slurry are shown in Table 1. The amount of organic nitrogen is smaller in the treatment than in the control. The amount of ammonium is higher, and more of the ammonia in the swine slurry is captured as ammonium.

Table 1. Total nitrogen in swine slurry

	Treated slurry	Untreated slurry
N as ammonia	**74%**	**69%**
N as urea	**22%**	**24%**
N as organic and not accessible	**4%**	**7%**
Accessible N	**97,5%**	**92,9%**

Table 2. Utilization of Nitrogen

	2001	**2002**
Treated slurry	**79%**	**81%**
Non treated slurry	**39%**	**54%**

The plant-available nitrogen is increased in the treated slurry, making the treatment swine slurry a better fertilizer. Field experiments in both 2001 and 2002 in winter wheat show a significant much higher utilization of the nitrogen in the acid treated slurry compared with non-treated slurry resulting in higher yields. The field experiments were carried out by a t-test.

Table 3. Treated slurry in wheat production

	Yields and results 100 kg/ha 2001	**Yields and results 100 kg/ha 2002**

No nitrogen	51,0	33,7
50 kg N	+5,4	+15,4
100 kg N	+12,7	+23,2
150 kg N	+18,7	+21,2
200 kg N	+16,5	+28,8
50 kg N + 100 kg NH_3-N in ***untreated*** slurry	+12,3	+27,7
50 kg N + 100 kg NH_3-N in ***treated*** slurry	+19,5	+31,4

Effects on economy

As the study is planned to end December 2003, we are still collecting data to make a full economic description of the system. The result so far seems that this system will give the farmer a profit, as a result of the improvement of the slurry as fertilizer and the slightly higher daily gain in the pig production.

Perspectives

The system is still under development. An expansion with a new separation system to separate the sulphuric acid treated slurry to pure water and fractions of high concentrated slurry and a nitrogen-potassium containing liquid fertilizer is being developed. This separation system is patented, and during the next 6 months study of this system will take place.

Conclusion

The technical procedure described reduces the amount of ammonia loss from pig farming with 75%. In addition there is a reduction in the dust concentrations in a swine confinement building.

The prevention of ammonia emission kept the nitrogen in the swine slurry, improving the slurry as fertilizer.

The average weight gain of pigs in the treatment sections is slightly increased. Expenses for the environmental improvement method could be covered by improved pig performance and by improvement of swine slurry as fertilizer. A substantial improvement in the working environment in swine confinement buildings seemed also to be achieved.

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