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Ammonia measurements above slurry lagoons

Comparative trials of ammonia emissions from a lagoon and a traditional open slurry silo were carried out under identical topographical and meteorological conditions. These showed that the measured ammonia emissions lay within the ranges given in the literature. The ammonia emissions from the lagoon from calculations based on the actual slurry surface area and volumes were less than from the silo. Where the surface was well covered by floating material, ammonia emissions were notably lower.

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Literature

Literature details are available from the publishers under LT 02111 or via Internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm

It is known that ammonia emissions from stored slurry are influenced by many factors. So far it has not been possible to present a single general explanation, especially under practical conditions in that, in such situations, there is no optimum measuring method available. So far, ammonia emissions have been measured mostly in the laboratory or over small containers where the slurry has already been homogenised. The methods compared in [1] were not suitable for practical conditions, all of them showing substantial errors as well as requiring very many analyses.

The target of the investigations was to quantify as simultaneously and continuously as possible ammonia emissions over the lagoon and silo and also to determine the weather influences thereupon.

Trial method

The trial was conducted on a dairy farm (~ 90 GV) in Ravensburg district. Alongside the concrete slurry silo (Ø 12 m, 4.1 m deep, ~ 400 m^3 capacity with 70 m^3 pre-store capacity) a lagoon was established measuring 26 • 16 m at upper borders (= 494 m^2) and on the lagoon bed 3 m deep through the sloping walls measuring ~ 19 • 13 m (= 247 m^2; ~ 950 m^3 capacity; *fig. 1*). On the west side of the lagoon a weather station recorded temperature, air moisture, precipitation, wind direction and strength. Teflon tubes were positioned for taking air samples at 0.5 (to max. 1 m) above the slurry surfaces (Ø 4 mm; nine over the lagoon, four over the silo). Through these, air was sucked into the gas analyser. The background concentration of ammonia was measured at 4.50 m height.

Two methods were applied for determining the NH_3 concentration (trail 1, 2; *table 1*).

Trial 1: ammonia measurement by gas analyser

For continuous measuring of ammonia concentrations a BINOS® gas analyser from the firm Rosemount was applied which used the principle of non-dispersive infrared (NDIR) absorption spectroscopy in a measuring range from 0 to 100 ppm (resolution ± 0.15 ppm).

During the trial period from 17. 2. to 23. 5. 2000 the lagoon was covered with a normal floating cover (~10 cm). The slurry in the concrete silo was decked with a well-developed floating cover (~ 15 to 18 cm) which was partly overgrown with vegetation

The ammonia concentrations over the lagoon, reduced according to the background value, lay during the recording from 17. 2. to 24. 4. by low temperatures right on the limit of the analysing equipment resolution precision. Similarly low ammonia concentrations were measured over the lagoon as well as the silo from 24. 4. to 23. 5. even though the temperatures then were already almost summery. This led to the replacement of the measurement method with a non-continuous cumulating measurement method with gas wash bottles.

Trial 2: ammonia measurements using wash bottles

At the Institute for Agricultural Engineering the wash bottle technique for measuring ammonia emission was successfully applied in wind tunnel systems after the bringing-out of

Table 1: Measuring methods and test conditions

Period	Measurement method	Lagoon	Silo
Trial 1: 17.2.-24.4.2000	Gas analyser Continuous	Normal floating cover, continuously filled	Not measured
24.4.-23.5.2000	Gas analyser Continuous	Normal floating cover, continuously filled	Well-developed floating cover, without filling
Trial 2: 1.6.-31.7.2000 (Trial A)	Wash bottle Non-continuous	Normal floating cover, continuously filled	Well-developed floating cover, pumped fr. pre-storage
8.8.-11.9.2000 (Trial B)	Wash bottle Non-continuous	Normal floating cover, the same slurry	Normal floating cover, the same slurry

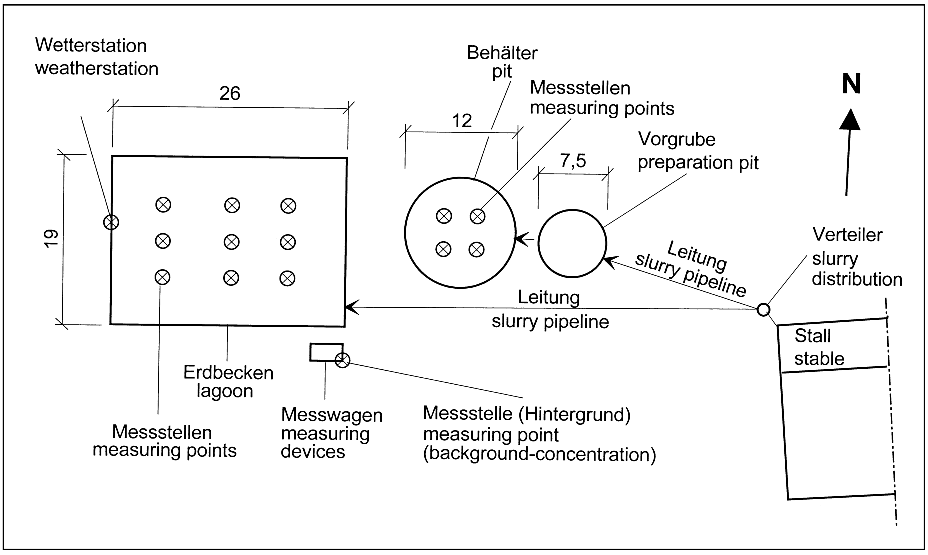

Fig. 1:Slurry pipelines from the stable to lagoon and pit as well as arrangement of measuring points

the slurry [2, 3]. According to the same principle the air containing ammonia was sucked in own trials 0.5 (to 1) m above the slurry surface and channelled to the wash bottles. The measurement points above lagoon and silo were in each case brought together to an airstream. For determination of background concentration the air was sucked from a height of 4.5 m. The sampling took place non-continuously through switching off pre-activated valves (every 5 min), after three days another wash bottle series was opened (= series): therefore the total ammonia from a whole day was contained in a wash bottle series. The analysis of NH_4^+-N concentration in the acid pre-storage container took place in the laboratory. The determination of the air volume flows (Ø 2.2 l/min) took place via thermal mass throughflow recorders F-111C (Bronkhorst) in that the emission was calculated as a time-related parameter out of the product of gas concentration and air volume flow which can, additionally, be related to areas or volumes.

In the total trial period 31 series of wash bottles were dealt with and evaluated. At first floating covers of differing thickness were investigated (trail A) whereby the lagoon (continuously filled) with „normally" developed floating cover (~8 to 10 cm) was compared with the silo (pumped full from pre-storage) with „well-developed" floating cover (~15 cm).

Finally, the slurry from the lagoon was pumped into the silo and homogenised (trial B). This enabled direct comparison between lagoon and silo with a nearly similar floating cover characteristics (~8 to 10 cm) and also almost identical slurry consistency.

The NH_3-N emission was on the one hand time-related, on the other it was based on the actual surface area in each case (lagoon: Ø 385 m^2; silo always 115 m^2), as well as the actual volumes (lagoon 500 to 666 m^3; silo: 180 to 300 m^3) (*table 2*) in order to be able to carry out a comparison with the values given in the literature. The average values of the recorded ammonia emission rates showed a high in the area of the currently known values in the literature (0.33 to 15.1 $g/m^2/d$) as well as in the lower range (1.0 to 18.8 $g/m^3/d$), whereby own-recorded values originated from substantially larger surface areas and volumes.

In trial A with floating covers of different thickness the absolute ammonia emissions from the silo were very low, whilst above the lagoon they lay at nearly 67 mg/h (*table 2*). The average emission rates based on the emitting surface areas as well as the actual volumes showed once again low emissions for the silo, however, in comparison no longer so much for the lagoon. Thus lower emission values were produced with (slurry containing less Nr. and) with a floating cover in the silo which was half as thick again.

In trial B with the same floating cover thickness and the same slurry the absolute ammonia emission over the lagoon (~ 54 mg/h) was only slightly higher than over the silo (just below 45 mg/h). Against this, emissions from the lagoon from calculations based on the slurry surface area were almost only a third of those out of the silo and nearly half when based on slurry volume.

According to the literature the size of surface area should influence the emissions. In that lagoons have a relatively large surface area it must be assumed that here more ammonia is emitted compared with from silos [4, 5, 6, 7].

Against this the vertical walls of a silo should produced many times more wind turbulence strength than sloping walls and with this be associated with a higher oxygen input as well as a more strongly emphasised air exchange with gas production thus increasingly encouraged [8, 9].

Own trials showed that the relative sizes of the emitting surface areas played a less important role when well-developed natural floating covers were present. Additionally, air turbulences and the amount of air exchange over the emitting surface area in the silo appear to lead to a relatively greater gas release in comparison.

The wind velocities measured in daily average from 1.4 m/s (peak velocity of 17.1 m/s = wind strength 7), but these allow no direct and exclusive influence of the amount of emissions to be observed as, e.g., presented in [10] and [11].

The practical trials were able to show that the ammonia emissions from the lagoon in comparison to the silo were in no case worse and instead when based on the surface area and volume came out even better, an important influence to be considered here, however, is the characteristics of the floating cover.

Table 2: Ammonia emission rates (reduced by background-concentration)

	Average value		
	Absolute mg/h	Area $g/m^2/d$	Volume $g/m^3/d$
Trial A	Different floating covers		
Lagoon	66,8	7,1	4,7
Silo	3,5	1,3	0,8
Trial B	same floating covers/ the same slurry		
Lagoon	54,2	6,2	4,6
Silo	44,7	16,2	7,2

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