Influence of slurry pretreatments and application techniques on ammonia emissions after landspreading of slurry on grassland.

Influence d'un prétraitement du lisier et des techniques d'épandage sur les émissions d'ammoniac après apport de lisier de porcs sur prairies.

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Abstract

More than half of the German ammonia emissions are caused by the landspreading of slurry. Aftereffects as loss of nitrogen fertilizer and environmental damages should be reduced through suitable processing improvements in slurry management. For recording the influence of different slurry pretreatments and application techniques on the ammonia emissions after landspreading of cattle slurry on grassland a system of three parallel operated windtunnels was used.

Landspreading of separated slurry reduced the ammonia volatilization by 72 % for the liquid phase and by 32 % for the solid phase. The liquid phase with a dry matter content of 3.1 % infiltrated very fast into the soil in contrast to the solid phase. However, the solid phase covered only about 1/3 of the grassland surface because of the higher dry matter content of 16.1 %.

The asumption that following a pretreatement of slurry with certain additives the ammonia emissions after landspreading are reduced, was not verified. The additives "Zeolit", "Biplantol G" and "BVG-mixture" had no effect on the emissions as well as an addition of untreated lime or treated lime "Penac G".

The application of anaerobically fermented slurry even increased the ammonia emissions by 23 % for the mesophil phase and by 47 % for the thermophil phase. The decrease of the dry matter content and it's reducing effect on the volatilization was covered from a very strong increase of the pH value, which caused higher emissions from the digested slurry.

Ammonia emissions could be reduced through application techniques which apply the slurry in narrow bands near or into the soil. In comparison to broadcast spreading with a splash plate, the nitrogen loss was reduced by 40 % using a trailing hose, by approximately 55 % using a trailing foot and even by 75 % using the trenching technique. The disadvantages of an application technique which incorporates the slurry into the soil are a higher draftforce requirement and an increase of *the CO_2 and N_2O emissions. Therefore the most suitable application techniques are the one which apply the slurry near the soil.*

Therefore the application techniques have a very high potential to reduce the ammonia emissions after landspreading of slurry, in contrast to the different pretreatements of the slurry, which can have a reducing effect or none effect or even a rising effect on the ammonia emissions.

Further researches on the influence of climatic conditions such as air temperature, soil humidity, windspeed and radiation are just under investigation.

Keywords : windtunnel, ammonia emission, slurry pretreatments, application techniques.

Résumé

Suite au fait que l'épandage de lisier cause plus de la moitié des émissions d'ammoniac de l'Allemagne et que souvent plus de 50% de l'azote du lisier sont perdus pendant l'épandage, une étude des facteurs qui influencent ces pertes, a été réalisée. Comme stations d'essai, trois tunnels ont été construits, qui permettent de mesurer au champ les émissions d'ammoniac en variant un seul facteur d'influence. La calibration des tunnels avec gaz d'ammoniac aboutit à un taux de recouvrement de 77 à 99% de l'ammoniac. Des investigations sur l'influence de différentes techniques d'épandage de lisier sur les émissions d'ammoniac, ont montré que comparativement à un épandage de surface, l'épandage à l'aide de « tuyaux traînés » diminue de 40% les émissions. Avec un « trailing foot » la diminution est de 55% et avec un soc d'enfouissage en ligne de 75%. Donc, les émissions peuvent être réduites si le lisier est épandu directement sur ou dans le sol. Une séparation du lisier avant l'épandage donne une réduction de 32% si seulement la phase solide est épandue et 72% pour la phase liquide. La phase solide couvre avec 16,1% de MS seulement un tiers de la surface et la phase liquide avec 3,1% MS est rapidement absorbé par le sol. L'utilisation des additifs « Zeolith » et « Biplantol G » n'a aucune influence sur les émissions d'ammoniac, de même que la poudre de chaux non pré-traitée et pré-traitée « Penac G ». Des investigations sur l'influence d'une fermentation aérobie et anaérobie avant l'épandage et sur l'influence des conditions climatiques pendant l'épandage sont à l'étude.

Mots-clés : tunnel, émissions d'ammoniac, techniques d'épandage de lisier, pré-traitement de lisier.

1. Materials and methods

For recording the factors of influence on the ammonia emissions after landspreading of slurry, the Institute of Agricultural Engineering of the University of Hohenheim developed a windtunnel system (Falk, 1994). A parallel operation of three windtunnels allows a specific variation of one influence factor under constant ambient conditions (fig.1).

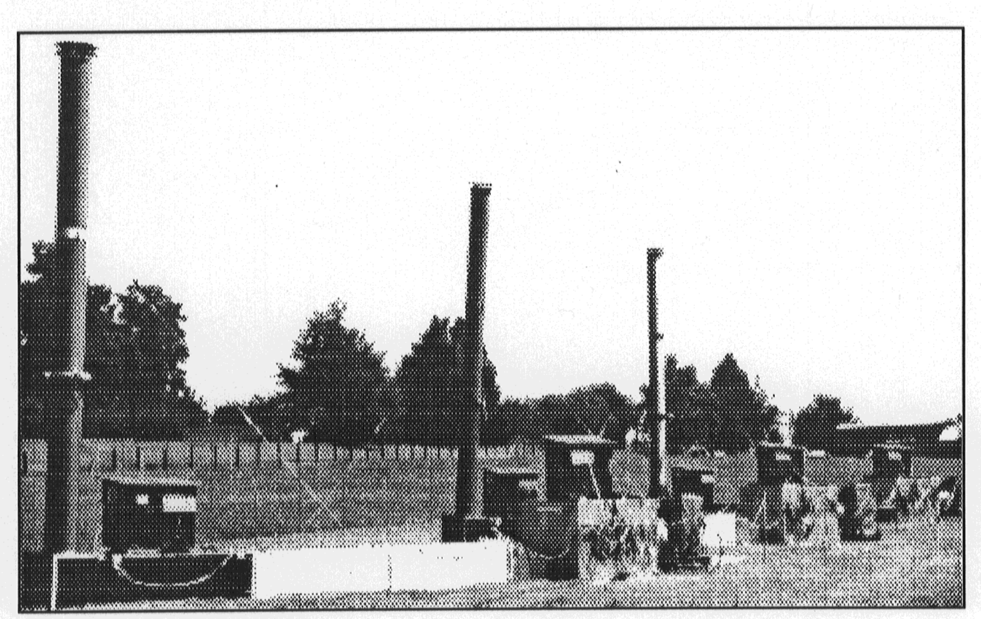


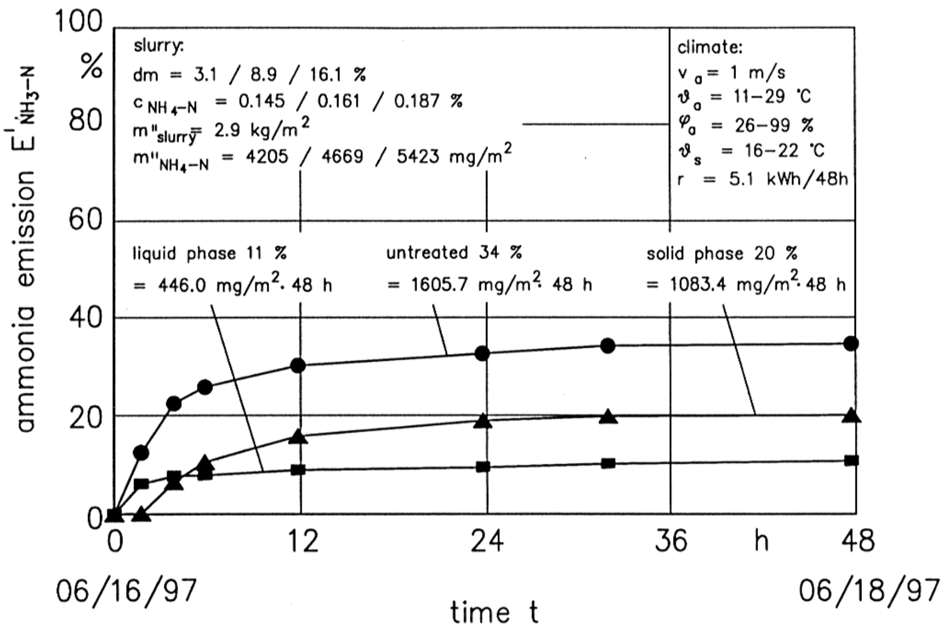
Figure 1
Windtunnel system of Hohenheim

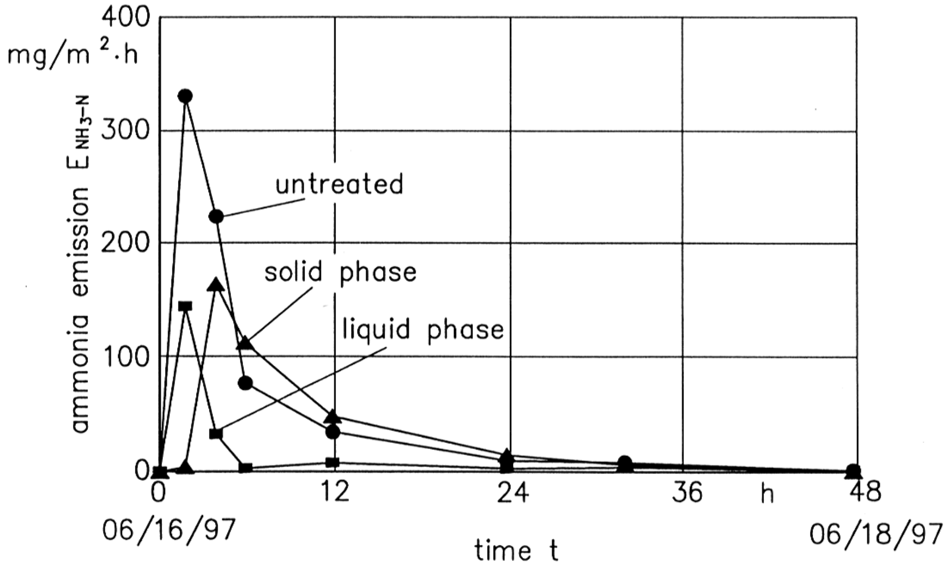
Researches on the accuracy of the windtunnel system gave percentages recovery ranging 77 % to 99 %. A representative sampling could be confirmed by the equality of the different samplers. An equalization of the three windtunnels gave a maximal NH_4-N difference of 200 mg/m² in 48 h (Reitz and Kutzbach, 1997). The accuracy of the Hohenheim windtunnel is similar to the one of other systems (Van der Weerden et al., 1996; Katz, 1996), thus, a reproducible quantification of ammonia emissions is ensured.

2. Results and discussion

So far researches on the influence of different slurry pretreatements and application techniques were carried out. As an example for the pretreatements the influence of a separation on the ammonia emissions is presented. Figure 2 and Figure 3 depict a comparison of an untreated slurry with the solid and liquid phase of a separated slurry. The ammonia emissions are shown in Figure 2 as the cumulative loss of NH_3-N expressed as the percentage loss of applied total ammoniacal nitrogen (TAN) from the slurry. Figure 3 presents the ammonia emission rates expressed in mg/m^2 h.

For the separation a cattle slurry with a dry matter content of 8.9 % and a NH_4-N concentration of 0.161 % was used. After the separation the dry matter content and the NH_4-N concentration of the liquid phase amounted to 3.1 % or 0.145 % respectively. The dry matter content of the solid phase was 16.1 %, the NH_4-N concentration amounted to 0.187 %. The amount of broadcast spread slurry was 2.9 kg/m², thus, the amount of ammonium nitrogen applied was 4669 mg/m² for the untreated slurry, 4205 mg/m² for the liquid phase and 5423 mg/m² for the solid phase. The climatic conditions during this research in June 1997 are also shown in Figure 2.





Figures 2 and 3
Influence of separation on ammonia emissions, comparison of a untreated slurry with the solid and liquid phase of a separated slurry

The highest nitrogen loss was found for the untreated slurry. Its total ammonia loss amounted to 1605.7 mg/m² in 48 h, that corresponds to a cumulative loss of 34 % of the TAN applied. By the solid phase emitted 1083.4 mg/m² in 48 h or 20 %. With a total loss of 446.0 mg/m² in 48 h or 11 % the liquid phase showed the lowest emission. The emissions of the untreated slurry were approximately two-fold higher than the ones of the solid phase and even threefold higher than the emissions of the liquid phase. If the emission of the untreated slurry is rated as 100 %, the loss of the solid phase is 68 % and the loss of the liquid phase 28 % of the amount of the untreated slurry. This corresponds to a reduction of the nitrogen loss of 32 % for the solid phase and of 72 % for the liquid phase.

The reduction potential of the separated slurry is explained through the changes in the dry matter content. Due to the lower dry matter content the liquid phase had a lower viscosity and inflitrated better and faster into the soil. Thus, an emitting surface existed only a short time, which is emphazised by the low emission peak of 144 mg/m² h^{-1} already 2 h after landspreading. As opposed to this the solid phase had with 163 mg/m² h^{-1} the highest emission rate 4 h after the application, because only one third of the grassland surface was covered with slurry. The solid phase stucked on the grassland plants because of the higher dry matter content, which explains the following higher emission rate. Caused by the great emitting surface the untreated slurry had with 331 mg/m² h^{-1} as well 2 h after landspreading an emission peak. Afterwards the emission rate of the untreated slurry declined faster than the one of the solid phase, since the slurry was better absorbed from the soil because of its lower dry matter content. For all three slurries approximately 90 % of the total emission occured already after 24 h. At the second day the emission rates were very low and the concentrations were only slightly over the background atmospheric ammonia concentration.

Pain et al. (1990) found corresponding reductions of the nitrogen loss by the liquid and solid phase of a separated pig slurry. Thompson et al. (1990) determined similar ammonia emissions from an unseparated slurry and a liquid phase of a separated slurry, because of a very small difference in the dry matter contents of only 1.5 %. In contrast to this Dosch (1996) found, a decrease of the nitrogen loss by the liquid phase, but an increase by the solid phase. In the sum of liquid and solid phase the ammonia emissions of the separated slurry were still less than the one of the unseparated slurry. Thus, the separation technique is an efficient possibility to reduce the nitrogen loss, provided that the change of the dry matter content is high enough.

A survey of the influence of further pretreatements and application techniques on the ammonia emissions after landspreading of slurry is given in Table 1. There are presented as the cumulative percentage ammonia emissions of different slurry additives, anaerob fermented slurry and slurry applied with different application techniques.

The addition of untreated lime or treated lime "Penac G" had no influence on the reduction of the ammonia emissions. Due to a very low dry matter content of 2.9 % and a very dry soil (soil moisture 14 %) all emissions were very low. Since the differences between the variations were smaller than the measurement deviations of the windtunnel system, no differences between those additives could be obtained. In the same way the ammonia emissions could not be reduced through the additives "Zeolit", "Biplantol" and "BVG-mixture". In oppose to this, Mannheim (1994) found under different conditions a reduction of the ammonia emission by 16 % using "Penac G". Martinez et al. (1997) examined five additives and could only determine a reducing effect for two. Moreover additives mainly influence the homogenization of the slurry and have only a limited effect on the reduction of ammonia emissions (Kunz, 1997).

influence factor	variation and cumulative percentage ammonia emission

additive	untreated	12 %	lime	17 %	Penac G	14 %
additive	untreated	29 %	Zeolit	29 %	Biplantol G	27 %
additive	untreated	30 %	Zeolit	31 %	BVG-mixture	29 %
anaerob fermentation	untreated	29 %	mesophil	36 %	thermophil	41 %
application technique	splash plate	27 %	trailing foot	13 %	trenching	6 %
application technique	splash plate	24 %	trailing hose	15 %	trailing foot	9 %

Table 1
Cumulative percentage ammonia emissions by different pretreatements and application techniques

Through an anaerobic digestion of the slurry during the production of biogas the ammonia emissions even increased by 23 % for the mesophil phase and by 47 % for the thermophil phase. The low decrease of the dry matter content from 6.0 % over 5.9 % to 5.5 % and it's reducing effect on the volatilization was covered from a very strong increase of the pH value from 7.5 over 7.9 to 8.1. Mannheim (1994) found similar increases, whereas by Pain et al. (1990) the nitrogen loss of the anaerob fermented slurry was slightly reduced. Therefore an anaerobic fermentation is only efficient, if the emission reducing decrease of the dry matter content is higher than the emission increasing growth of the pH value.

By means of application techniques which apply the slurry in narrow bands near or into the soil and therefore diminish the contact surface between slurry and atmosphere, the nitrogen losses can be reduced very efficiently. In comparison to broadcast spreading with a splash plate, the ammonia emissions could be reduced by 39 % using the trailing hose, between 52 % and 61 % using the trailing foot and even by 74 % using the trenching technique. Similar reduction potentials were found by Lorenz and Steffens (1996), Bussink (1997), Depta et al. (1997) and Frick and Menzi (1996). An application technique which incorporates the slurry into the soil has some disadvantages as a higher draftforce requirement and increasing CO_2 and N_20 emissions (Schürer and Reitz, 1998). Thus, application techniques which apply the slurry near the soil are the most suitable ones.

Since ammonia emissions are mainly influenced by the climatic conditions during the landspreading of slurry, further researches on the influence of air temperature, soil humidity, windspeed and radiation are just under investigation.

3. References

Bussink, W.: Ausbringtechniken auf Grün-und Ackerland in den Niederlanden. KTBL Arbeitspapier 242, Darmstadt, Germany, S. 218/226, 1997.

Depta, G., S. Neser, S.C. Becher, A. Gronauer, I. Steinicke, A. Sedlmaier and K. Schäfer: Distinction between Different Slurry Application by their Ammonia Emission with FTIR-Open-Path Measurements and Dispersion Modelling. Proceedings of the International Symposium on Ammonia and Odour Control from Animal Production Facilities, Vinkeloord, Netherlands, vol. 1, pp. 175/183, 1997.

Dosch, P. Optimierung der Verwertung von Güllestickstoff durch Separiertechnik und kulturspezifische Applikationstechniken. Dissertation TU München, Lehrstuhl für Pflanzenernährung, Gelbe Heftereihe Nr.56, 1996.

Frick, R. und H. Menzi: Hofdüngeranwendung: Wie Ammoniakverluste vermeiden? FAT Bericht Nr. 496, Eidgenössische Forschungsanstalt für Agrarwirtschaft und Landtechnik, Tänikon, Switzerland, 1996.

Katz, P.: Ammoniakemissionen nach der Gülleanwendung auf Grünland. Dissertation ETH Zürich Nr. 11382, 1996.

Kunz, H.-G.: Personal Informations. LVVG Aulendorf, Germany, 1997.

Lorenz, F. und G. Steffens: Gülleeinsatz auf Grünland mit unterschiedlichen Verteiltechniken. KTBL, Darmstadt, Germany, 1996.

Mannheim, T.: Ammoniakemissionen von landwirtschaftlichen Nutzflächen: Quellen und Minderungsmaßnahmen. Dissertation Universität Hohenheim, Institut für Pflanzenernährung, 1994.

Martinez, J., J. Jolivet, F. Guiziou and G. Langeoire: Ammonia Emissions from Pig Slurry: Evaluation of Acidification and the Use of Additives for Reducing Losses. Proceedings of the International Symposium on Ammonia and Odour Control from Animal Production Facilities, Vinkeloord, Netherlands, vol. 1, pp. 485/492, 1997.

Pain, B.F., T.H. Misselbrook, C.R. Clarkson and Y.J. Rees: Odour and Ammonia Emissions Following the Spreading of Anaerobically-Digested Pig Slurry on Grassland. Biological Wastes 34, pp. 259/267, 1990.

Pain, B.F., V.R. Phillips, J.F.M. Huijsmans and J.V. Klarenbeek: Anglo-Dutch experiments on odour and ammonia emissions following the spreading of piggery wastes on arable land. Research Report 91-9, IMAG-DLO Wageningen, Netherlands, 1991.

Reitz, P. and H.D. Kutzbach: Accuracy of a Windtunnel System for Measuring Ammonia Emissions after Slurry Application. Proceedings of the International

Symposium on Ammonia and Odour Control from Animal Production Facilities, Vinkeloord, Netherlands, vol. 2, p. 595/598, 1997.

Schürer, E. and P. Reitz: Emissionen von Ammoniak und Lachgas - Einfluß des Ausbringverfahrens von Flüssigmist. Landtechnik 53, Nr. 1, S. 36/37, 1998.

Thompson, R.B, B.F. Pain and D.R. Lockyer: Ammonia volatilization from cattle slurry following surface application to grassland - influence of mechanical separtion, changes in chemical composting during volatilization and the presence of the grass sward. Plant and Soil 125, p. 109/117, 1990.

Van der Weerden, T.J., J.F. Moal, J. Martinez, B.F. Pain and F. Guiziou: Evaluation of the Wind-Tunnel Method for Measurement of Ammonia Volatilization from Land. Journal of Agricultural Engineering and Research 64, p. 11/14, 1996.