Petra Reitz and Elke Schürer, Hohenheim

Rainfall reduces NH_3 and CH_4 emissions

Emissions of ammonia, nitrous oxide and methane following slurry manure spreading

The amount of NH_3, N_20 and CH_4 emissions during the spreading of slurry manure is especially influenced by prevailing weather which is why the effect of different levels of rainfall on emissions has been investigated. Ammonia and methane emissions were reduced in line with increasing rainfall. Under the same conditions, emissions of nitrous oxide emissions increased. In that the percentage of Nr. loss in the form of ammonia emissions is substantially higher than the nitrous oxide emissions, slurry should be spread before rainfall for more efficient Nr. exploitation.

Dipl.-Ing. agr. Petra Reitz and Dipl.-Ing. agr. Elke Schürer are members of the scientific staff at the Institut für Agrartechnik, specialist area Verfahrenstechnik in der Pflanzenproduktion mit Grundlagen der Landtechnik (director: Prof. Dr.-Ing. H.D. Kutzbach) der Universität Hohenheim, Garbenstr. 9, 70599 Stuttgart; e-mail: schirmer@uni-hohenheim.de, Eschuerer@yahoo.de

Keywords

Emissions of ammonia, nitrous oxide and methane, slurry application, rainfall

Literature details are available from the publishers under LT 99603 or via Internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm

Intensive livestock enterprises in agriculture are one of the main causes of ammonia (NH_3), nitrous oxide (N_2O) and methane (CH_4) emissions. NH3 has a polluting effect in the environment whereas N_2O and CH_4 are gases directly relevant to the climate [1]. Several influencing factors were investigated relating to the emissions of NH_3, N_2O and CH_4 after the spreading of slurry manure on grassland such as the technique of manure application, prior handling of the manure and prevailing weather conditions [2,3]. In the investigation described here the aim was to test how differing amounts of rainfall immediately after the spreading of slurry affected the emissions of NH_3, N_2O and CH_4.

Implementation of the investigations

Investigation of the NH_3 emissions was carried out in August 1998 at Hohenheim whilst the N_2O and CH_4 emissions were recorded in the Allgäu. For this, three wind tunnels and eight measuring-chamber systems were used in parallel [2,3]. The influence of rainfall of 0, 7 and 14 mm was investigated. In the case of the NH_4 emissions, the three rainfall variations were investigated at the same time [2]. For the variant with zero rainfall, the results regarding N_2O emissions were brought-in from results of an investigation carried out in June 1997. The CH_4 emissions related to the results from several investigations. In *table 1* the slurry composition and the amount spread, as well as the climatic conditions during the investigations, are given.

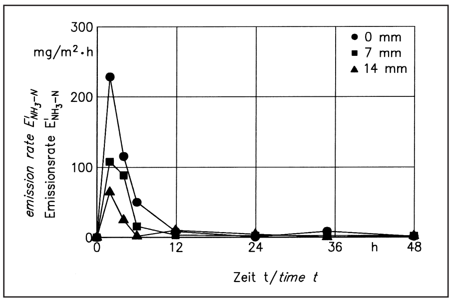

Fig. 1: Influence of rainfall on NH_3-N emission rates

Used was the kind of diluted cattle slurry typical for the Allgäu and this was evenly spread over a broad area by a watering can with spray plate attachment . Immediately afterwards, rainfall was simulated by water applied with a watering can with rose attachment. The investigation with NH_3 lasted two days. The N_2O investigations lasted 10 or 14 days and the CH_4 emissions were investigated over nine hours.

Emissions of ammonia, nitrous oxide and methane

With the NH_3-N emissions as well as the CH_4 emissions the highest emission rates were recorded immediately after the slurry spreading (*figs. 1 and 3*). With zero rainfall, the highest cumulative NH_3-N and CH_4 emissions were determined (*table 2*). Compared with these results, the NH_3-N emissions were reduced by 45% by 7 mm rainfall and by 67% by 14 mm of rain [2]. With CH_4 the emissions were reduced by 29% and 59% respectively by the same amounts of rain. In that the CH_4 emissions had in part declined

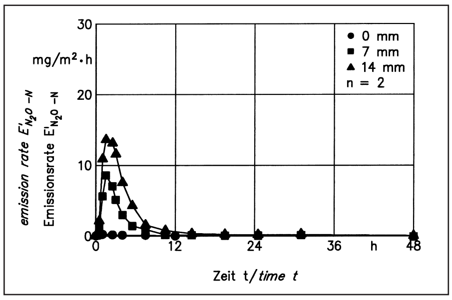

Fig. 2: Influence of rainfall on N_2O-N-emission rates

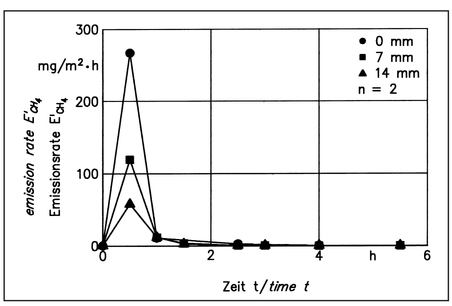

Fig. 3: Influence of rainfall on CH_4-emission rates

Table 1. Slurry analysis and weather during trials

Slurry		DM [%]	pH	C_{NH4-N} [g/kg]	m''_{FM} [kg/m²]	m''_{NH4-N} [mg/m²]
NH_3	0, 7, 14 mm	5,8	7,6	1,37	2,9	3973
N_2O, CH_4	0 mm	5,9	7,0	1,24	3,0	3720
N_2O, CH_4	7, 14 mm	5,2	7,2	1,15	3,0	3435
Climate		δ_L [°C]	φ_L [%]	δ_{BO} [°C]	U_{BO} [%]	R [W/m²]
NH_3*	0, 7, 14 mm	18-36	20-100	20-35	13-20	0-300
N_2O, CH_4	0mm	15-26	50-92	17-20	31-33	0-283
N_2O, CH_4	7, 14 mm	16-34	31-100	18-26	15-22	0-766

*v_L in Windtunnel =1 m/s

Table 2: Summary of experiment results

Emissions	cum. abs. emissions [mg/m²]			cum. rel. emissions [% NH_4-N]		Changes [%]		
Gas	NH_3-N	N_2O-N	CH_4	NH_3-N	N_2O-N	NH_3-N	N_2O-N	CH_4
Time	2 d	10-14 d	3-9 h	2d	10-14 d	2d	10-14 d	3-9 h
0 mm	941	22	298	24	0,6	-	-	-
7 mm	518	81	213	13	2,4	-45	+268	-29
14 mm	311	142	123	8	4,1	-67	+546	-59

below the background emission after only three hours, the calculation of the cumulative emissions were shortened accordingly. Through the rainfall the slurry was diluted and washed from the plants so that infiltration into the ground was substantially improved. Additionally, the concentration of NH_3 and CH_4 in the slurry was reduced as was the partial pressure, through which less NH_3 and CH_4 was released from the slurry. In the literature the NH_3-N emissions were mostly investigated with a rainfall of 10 mm. In association with other factors such as, for example, soil moisture or DM content, the determined emission reductions were scattered in an area from 48 to 89% [4,5,6] and are comparable with own results in [2]. With regard to the CH_4 emissions, there have been no applicable investigations so far.

Only through intensive or long periods of rainfall is a substantial reduction of emissions possible. In that the majority of the NH_3-N and CH_4 emissions occur in the first hours after spreading, the emission-reducing effect is all the higher the shorter the time-span between spreading and rainfall [2, 3, 7, 8].

In contract to this, the N_2O-N emissions were heightened to an extreme extent in correlation with increasing rainfall. Rainfall of 7 mm caused an increase in emissions of just under 270%. Here too, the highest emission rates were recorded shortly after spreading (*fig. 2*).The N_2O was produced to a greatest extent through the denitrification of nitrate (NO_3) in the soil whereby the denitrification rate increases in-line with the moisture content of the soil [9]. If easily-soluble organic substances are also washed out of the slurry by the added water, the denitrifying bacteria have thus an additional source of energy. The highest N_2O emissions finally then occur when at the same time as the denitrification, nitrification as a source of NO_3 also takes place [10]. This especially occurs where slurry application includes a high addition of NH_4- N.

Evaluation of total emissions

In order to assess the emission-reducing effect of an influencing factor with regard to all the gases emitted, the greenhouse potential of the different gases were converted to CO_2 equivalents. N_2O has 270 times, and CH_4 11 times, the greenhouse effect compared with CO_2 [1] . A calculation of the specific greenhouse potential for NH_3 is, however, difficult in that this has only an indirect climate influence. According to [11] it's possible to calculate a simplified conversion factor of 110 for NH_3, although this is not recognised overall. In *figure 4* the cumulative absolute NH_3, N_2O and CH_4 emissions are presented. According to the above-mentioned problem, only the N_2O and CH_4 emissions were converted into CO_2 equivalents. If the factor 110 is used for NH_3, then the highest total emissions could be expected in dry weather. In this case, an effective reduction of emissions could be achieved by applying slurry just before rainfall. If the NH_3 factor lay by 80 [12], then there would be hardly any difference to be recorded between the total emissions from the rainfall variants investigated here.

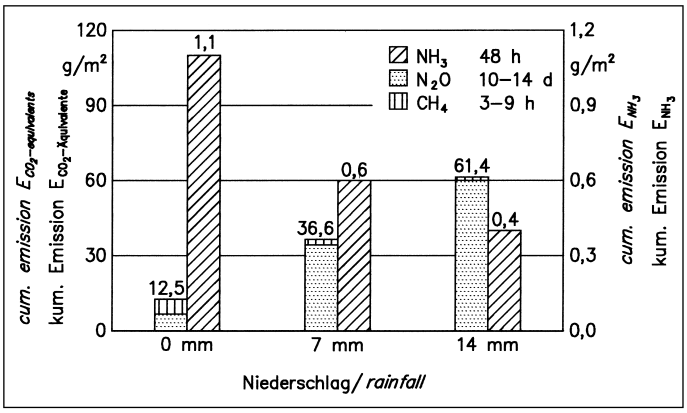

Fig. 4: Cumulative NH_3-, N_2O- and CH_4-emissions, N_2O and CH_4 calculated as CO_2-equivalents

Conclusion

The evaluation of an emission-reducing effect of any influencing factor depends to a great extent on the conversion factors applied for each gas. As long as there are no generally applicable factors in existence, the farmer cannot be given concrete advice regarding the reduction of emissions of environment and climate relevant gases. However, an efficient Nr. exploitation can already be achieved through spreading slurry before rainfall in that the percentage NH_3-N loss is substantially higher than the N_2O-N loss. If, at the same time, attention is paid to keeping the Nr. application to a level not more than that required by the growing plants, this means that the N_2O emissions, too, can be decreased [13].