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Emissions During Manure Composting

Environment-relevant gases released during manure composting were investigated. It was shown that emissions of ammonia and methane reduce over a period of three to four weeks. The release of nitrous oxide shows a substantially higher variability regarding time and locality, maximum releases of nitrous oxide were noted mainly after the reduction in ammonia and methane emissions. The mean emission as well as the emission relationship can serve to characterise the environmental effect. The measured loss of gas-form nitrogen during the manure composting was on average 6%, the carbon loss around 35%.

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Emission data are required for the evaluation of the environmental effects of agricultural procedures. The main processes which lead to the creation of trace gases have already been thoroughly investigated. Nitrous oxide (NO_2) emissions from livestock production are mostly less than manure-induced emissions in cropping. Depending on the production system they can, however, represent an important strain of the enterprise's environment balance. Main source of agricultural methane (CH_4) emissions in Germany is cattle production. From the animal excrement also escapes ammonia (NH_3) created through enzymic hydrolysis of urine. Type of livestock and housing, as well as storage and treatment of the excrement, have a major influence on the production rate of N_2O, CH_4 and NH_3 [1 to 3]. For exact nutrient balances in organically managed enterprises, the substance release into the atmosphere during manure composting were to be investigated and for this purpose the compost gas releases over a period of six composting periods in 1998 and 1999 were recorded and evaluated under practical conditions.

Manure treatment through composting

The investigations on release of gases during manure composting were carried out on the farm of Marienhöhe in Bad Saarow which has been organically managed since 1928. The amount of manure from the cattle and pig houses (daily (1000 kg) was stored in trapezoid compost heaps. The heaps were layered with fresh manure at periods every six to 13 weeks. The depth of each fresh manure layer of about 30 cm allowed a good throughflow of air during the composting process and meant that no turning-over was required. With a maximum of five layers there was created, as a result of the rotting process, compost heaps of up to 1.2 m in height. Manure has been treated in this way for decades on the biofarm and experience has shown that it gives a careful and low-labour method of processing solid manure.

Emissions during the storage and composting of slurry and solid manure have been intensively investigated in recent years by several authors. An increase in pH value, temperature or in the ventilation increased NH_3 emissions [4], where C/N relationships are high, the NH_3 emissions decrease [5]. Maximum production rates of N_2O can be seen where there is not a large enough supply of oxygen in the rot, e.g. when through a high biological activity the oxygen partial pressure in the rotting material falls to zero [6]. Intensive ventilation in association with a low C content leads to a nitrite accumulation in slurry (up to 33% of the total nitrogen content) [7] and incomplete ammonia oxidation. The measurement of emissions during the storage of slurry and the composting of solid manure gave a N_2O-N release of up to 6% of the original nitrogen content. The NH_3 emissions with solid manure composting were as a rule less than 5% of the original nitrogen content [4, 8]

Collecting gas samples

Two gas samples were taken weekly at seven measuring points where fresh manure from seven subsequent days of production was de-

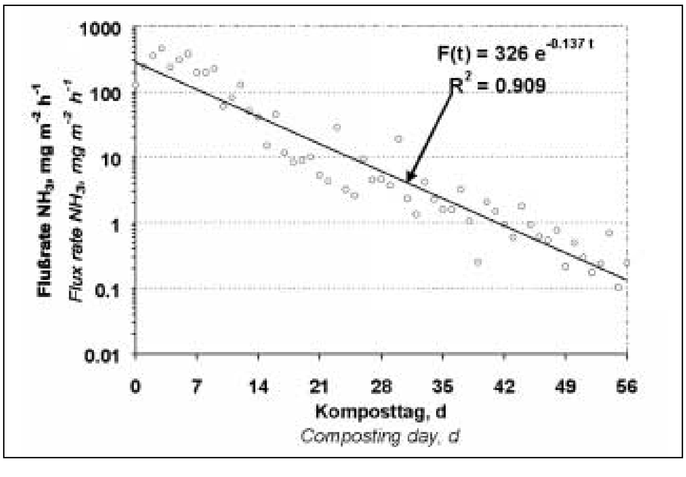

Fig. 1: NH_3-Emissions with exponential trend function $F(t) = 326\ e^{-0.137}\ t$ for 56 composting days with a coefficient of determination of R^2 = 0.909 on a logarithmic scale (Means of six composting periods)

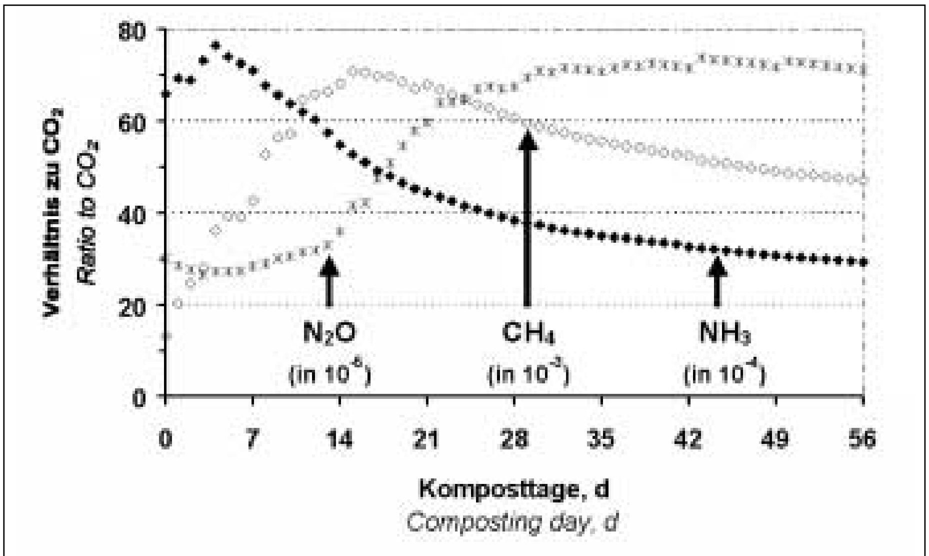

Fig. 2: Accumulated emissions in relation to accumulated CO_2-emissions (Means of six composting periods)

posited. From this weekly sampling it was possible to create a daily time-scale in the investigation of the emission progress. The gas flux chamber technique was used for determining the emissions from the compost. The cylindrical PVC chambers had a volume of 0.189 m^3 and a ground area of 0.292 m^2. After ten minutes gas collection, the gas bag was filled and analysed via a Fourier Transformation Infrared Spectrascope (FTIR). On every measuring day, three on-the-spot samples were taken of the air outside (before, during and after the sampling). This was because the concentration differences to the air were required in the calculation of emission values.

Emission progression during manure composting

During a composting period, the emissions of ammonia and methane within the first three weeks reduce almost completely. The nitrous oxide emissions, however, are very variable over the whole composting period with the tendency to increase in line with the decrease of CH_4 and N_2O. Maximum values are measured after two to six weeks. After that, the N_2O production decreased slowly. This typical behaviour was observed with all the composting periods investigated. The highest amounts of released ammonia was released two to five days after the depositing of the manure, then the emission values decreased. The maximum rate of emissions with NH_3 lay by around 0.1 to 0.9 g m^{-2} h^{-1} with a maximum mean of around 0.3 g m^{-2} h^{-1}. The digression trend for ammonia emissions (fig. 1) can be depicted approximately by an exponential decrease up until eight weeks after the beginning. This form of progression is produced with constant reduction reactions , e.g. proportionality between reduction rate (emission) and transformable material. Original materials behind the release of NH_3 are dissolved NH_3, NH_4^+- ions and urine, as well as further organic-bound nitrogen in the substrate. The trend function for NH_3 had a coefficient of determination R^2 of 0.909 with a digression time (1/e-reduction) of seven days. Methane source is taken as an anaerobic degradation within excrement particles. Methane emissions can be detected up to around 10 weeks after beginning and show an exponential decrease. With CH_4, one becomes an R^2 of 0.737 with a digression time of ten days for a eight week composting period as well as a ten week one.

As average emission per composting period over the six composting periods, 1322 g m^{-2} for CH_4, 76.9 g m^{-2} for NH_3 and 19.8 g m^{-2} for N_2O were released. When these total emissions are related to the mean of the CO_2 amounts created in the composting periods, indicator values of around 4.6 10^{-2} for CH_4, 2.7 10^3 for NH_3 and 6.9 10^{-4} for N_2O were produced. These emission relationships do not represent constant parameters but instead depend as a quotient of the progression of the accumulated emissions (fig. 2). Not until the end of the rotting period do constant values appear in that, from that time on, no further emissions can enter the accumulation. If one balances the average emissions of the composting periods (table 1) this gave a loss proportion of 4.1% carbon for methane compared with the carbon content in the dry matter of the fresh manure. The nitrogen loss from the originally deposited NH_3-N represented 5.2% of original nitrogen, the Nr. loss through release of N_2O-N was around 1%. Compared to the results given above for composting of solid manure [4] the ammonia emissions are roughly the same and the nitrous oxide emissions are less. On the average of the composting periods, around 35% of the original carbon content was utilised as an energy source for microbial action during composting.

Key conclusions

The composting of manure leads to comparatively high carbon losses. Ammonia emissions cause the main part of nitrogen losses. The emission values measured here under practical conditions represent the accepted amounts found in the literature. The relatively low nitrous oxide emissions in relation to original content, are evidence of sufficient ventilation and of the environmentally-friendliness of the layer-composting method. Despite layering of fresh manure deposits, the methane emissions could not be avoided. Taken as methane source was the excrement in the manure.

	Manure data [kg]	Emissions as proportions of C or N in DM [%]	
Fresh manure amount	7473	CO_2-C-Anteil	31,3
Dry matter proportion	1831	CH_4-C-Anteil	4,1
Carbon proportion	824	NH_3-N-Anteil	5,2
Nitrogen proportion	41	N_2O-N-Anteil	1,0

Table 1: Composition of solid manure and total emissions (Means of six composting periods)