Emissions of NH_3, N_2O and CH_4 from composted and anaerobically stored farmyard manure

Emissions de NH_3, N_2O et CH_4 lors du stockage de fumier composté ou stocké en anaérobie.

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Abstract

A large open-dynamic-chamber has been developed and is now used to asses the emissions from all sectors of animal husbandry. It covers an area of 27 m^2 and can be built up over different emitting surfaces or manure heaps. It enables emission measurements of up to 8 t of manure under practical conditions. The compost emitted more NH_3 (823 g/t) than the anaerobically stored solid manure (287 g/t). The NH_3 emission from the compost amounted to about 10% of the total nitrogen content of the fresh manure. Half of the total emissions of the anaerobically stored solid manure was emitted after spreading. The compost did not emit any NH_3 after spreading. The results show the importance of measuring emissions during storage as well as during and after spreading, if emissions of different treatments are to be evaluated. Anerobically stored solid manure emitted much more greenhouse gases (N_2O : 74.7 g/t and CH_4 : 1493.8 g/t) than the compost (N_2O : 49.8 g/t and CH_4 : 151.1 g/t). If environmentally friendly manure management systems are to be found, it is n ot sufficient to measure only one gas. The emissions of NH_3, CH_4 and N_2O have to be considered and reduced.

Keywords : emission measurement, solid manure, ammonia, methane, N_2O.

Résumé

Les émissions gazeuses sont mesurées à l'Institut d'Ingénierie pour l'Agriculture et l'Environnement (ILUET) à l'aide d'une chambre ouverte dynamique qui couvre une surface de 27 m². Cette chambre permet de mesurer les émissions issues de tas de plus de 8 t. de produit. Le fumier composté émet davantage d'NH_3 (823 g/t) que celui géré de façon anaérobie (287 g/t). Le fumier géré en conditions anaérobies émet davantage de gaz à effet de serre : N_2O : 74.7 g/t et CH_4 : 1493.8 g/t que celui composté : N_2O : 49.8 g/t et CH_4 : 151.1 g/t.

Mots-clés : mesure émisions, déjections solides, ammoniac, méthane, protoxyde d'azote.

1. Introduction

Farmyard manure can either be anaerobically stored or aerobically composted. Most of the investigations that have been carried out so far concentrated on ammonia emissions from composted FYM (DEWES 1996, RÖMER ET AL. 1994). Recently also N_2O and CH_4 emissions have been included in the measurements on the laboratory scale (e.g. HÜTHER ET AL. 1997, OSADA ET AL. 1997). Emission measurements should be carried out under field conditions and should include all ecologically harmful gases. As the way of storing farmyard manure influences the change of manure composition (esp. NH_4 content) and as the composition of the farmyard manure influences the amount of ammonia emissions after spreading (MENZI ET AL. 1997), the emissions during storage and after spreading of the manure should be included in the investigations.

2. Experimental

If the emission rate is to be determined, gas concentration and air flow have to be known. Concentrations of NH_3, N_2O and CH_4 are analysed by a high resolution FTIR spectroscope. For the determination of the air flow over manure storages and during and after spreading of manure the ILUET has developed a large open-dynamic-chamber (AMON ET AL. 1997). It is described in "Emissions of NH_3, N_2O and CH_4 from a tying stall for milking cows, during storage of solid manure and after spreading" in these proceedings.

The ILUET compared emissions from anaerobically stored and aerobically composted FYM from a tying stall for milking cows under summer and under winter conditions. The summer period lasted from June to September 1996, the winter period from march to June 1997. Two heaps of farmyard manure were stored on concrete slabs with a drainage system. Seepage water emissions during storage were collected and analysed for their N content. The temperature in the two heaps was measured continuously at six places in each heap. Table 1 shows the composition of the composted and the anaerobically stored FYM and the mean temperature inside the manure heaps. The large open-dynamic-chamber was moved from one heap to the other three times a week to measure the emissions. In the summer trial each manure heap consisted of 3.5 t of farmyard manure. In the winter trial about 7t of farmyard manure were investigated.

	DM [\%]	Nt [kg/t]	NH4-N [kg/t]	C/N	pH	temp. [°C]
summer						
composted FYM (su)	28.3	6.60	1.10	14	7.55	45.0
anaerobically stored FYM (su)	20.4	6.39	1.17	14	7.43	35.3
winter						

composted FYM (wi)	22.1	6.69	0.63	16	8.70	34.3
anaerobically stored FYM (wi)	21.2	6.31	0.43	15	8.20	22.4

Table 1.
Composition of the farmyard manure and mean temperature inside the manure heaps

One heap was composted aerobically, which means it was turned seven times during the storage period. The turning was performed by hand. The large open-dynamic-chamber was built up over the compost and collected the emissions during and after the turning. The other heap was stored anaerobically. No manipulations were performed during the storage period.

After the storage period the large open-dynamic-chamber was built up on grassland and the composted and the anaerobically stored FYM were spread in the chamber. The amount of spreaded manure was equivalent to 20 t/ha. Emissions during and after spreading were also measured so that the sum of emissions (storing, turning and spreading) could be determined. The spreading of the summer trial was performed in September 1996. The temperatures were low during the spreading of the farmyard manure (10°C). The farmyard manure from the winter trial was spread at the beginning of June 1997 under warm conditions (20°C).

3. Results

3.1. Emissions during storage and after spreading or farmyard manure.

Table 2 shows the ammonia emissions during storage and after spreading of composted and anaerobically stored FYM from the summer and winter trials. Ammonia emissions after spreading are given in reference to the amount of farmyard manure at the beginning of the storage period to make a comparison possible between the different trials and the different ways of ammonia losses.

In both trials the compost emitted more NH_3 than the anaerobically stored FYM. However NH_3 emissions from the winter compost were much lower than from the summer compost. This was due to heavy snowfall at the beginning of the winter storage period. The snow fell on the warm heap, melted and drained into the compost. Thus the oxygen supply inside the heap was very low and the composting process did not proceed well. The low temperatures inside the winter compost (table 1) also show, that due to the high water content the composting was not optimal. At the end of the storage period the winter compost was not crumbly and fragrant, but muddy and evil-smelling.

	NH_3-losses [g NH_3/t FM[a]]			
	Storage	turning	spreading	*Sum*
composted FYM (su)	643.3	27.2	---	*670.5*
anaerobically stored FYM (su)	162.7	---	85.3	*248.0*
composted FYM (wi)	302.6	---	---	*302.6*
anaerobically stored FYM (wi)	46.2	---	197.3	*243.5*

[a] FM = fresh matter

Table 2.

After spreading of the compost no ammonia emissions were detectable. This corresponds well to the results of MENZI ET AL. (1997) who found a correlation between ammonia emissions and NH_4-N content and lower ammonia emissions from strongly decomposed FYM than from fresh farmyard manure. The summer and the winter compost did not contain any NH_4-N at the end of the storage period and therefore no NH_3 was emitted after spreading.

A considerable part of the ammonia emissions from the anaerobically stored FYM did not occur during storage, but after spreading. In the summer trial about 35% of the total NH_3 emissions emitted after spreading, in the winter trial this share amounted to 81%. The following explanations can be found for this phenomenon: The summer farmyard manure was spread in September under relatively cold weather conditions and at a very low wind speed. Both factors reduce ammonia losses after spreading. The winter farmyard manure had a high water content that led to low NH_3 emissions during storage. The spreading was done at the beginning of June under warm weather conditions and at a wind speed of about 0.4 m/s. The ammonia emissions from the summer trial corresponded to 2.8 kg NH_3/ha, those from the winter trial to 5.74 kg NH_3/ha. The first value is very low compared to emissions found by other authors due to the conditions explained before. The second value corresponds well with data from the literature. MENZI ET AL. (1997) found mean NH_3 emissions of 52% of the spreaded NH_4-N. CHAMBERS ET AL. (1997) give NH_3 emissions after spreading of cattle FYM of 8.6 kg NH_3/ha. This value is higher than that found in our investigations probably due to the higher application rate (30.6 t/ha).

Table 3 shows the total N losses of composted and anaerobically stored FYM from the summer and winter trials. The sum of N emissions results from gaseous NH_3 and N_2O emissions and from liquid N emissions in the seepage water (NO_3, NH_4).

The total N emissions of all trials showed no major differences and amounted to 6.47-10.84% of the N content of the farmyard manure at the beginning of the storage period. However the distribution of the emissions to the investigated sources differed considerably. This shows the importance of measuring all sources of N emissions if the ecological impact of the treatments is to be evaluated.

	N losses [g N/t FM[a]]				
	NH_3-N	N_2O-N	N in sea-page water	*Sum*	% of total N
composted FYM (su)	552.2	23.9	141.5	*717.6*	10.84
anaerobically stored FYM (su)	205.7	36.5	260.1	*502.3*	7.79
Composted FYM (wi)	249.2	30.0	200.1	*479.3*	7.60
Anaerobically stored FYM (wi)	201.3	55.6	181.9	*438.8*	6.47

[a] FM = fresh matter

Table 3.
N losses during storage and after spreading of composted

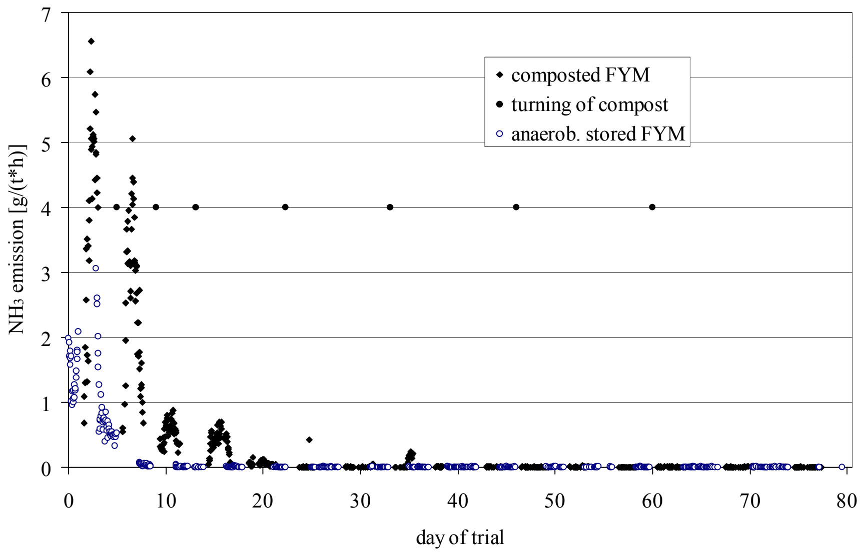

Figure 1.
Course of NH_3 emissions from composted and anaerobically stored FYM (summer)

NH_3 emitted mainly at the beginning of the storage period. Figure 1 shows the ammonia emissions from composted and anaerobically stored FYM (summer). Emissions were high at the beginning of the storage but decreased rapidly. This course of emissions was observed also from the winter trials, but NH_3 emissions stayed on a lower level than during the summer trials (table 2).

The course of CH_4 emissions differed from the course of ammonia emissions (fig. 2). CH_4 emissions from the anaerobically stored FYM kept on a high level throughout the whole storage period. The decrease of CH_4 emissions in course of the storage period was slow and they were still detectable at the end of the trial. That means that if the anaerobically stored FYM had been stored for a longer time, the sum of emissions would have increased. CH_4 emissions from the compost were always low.

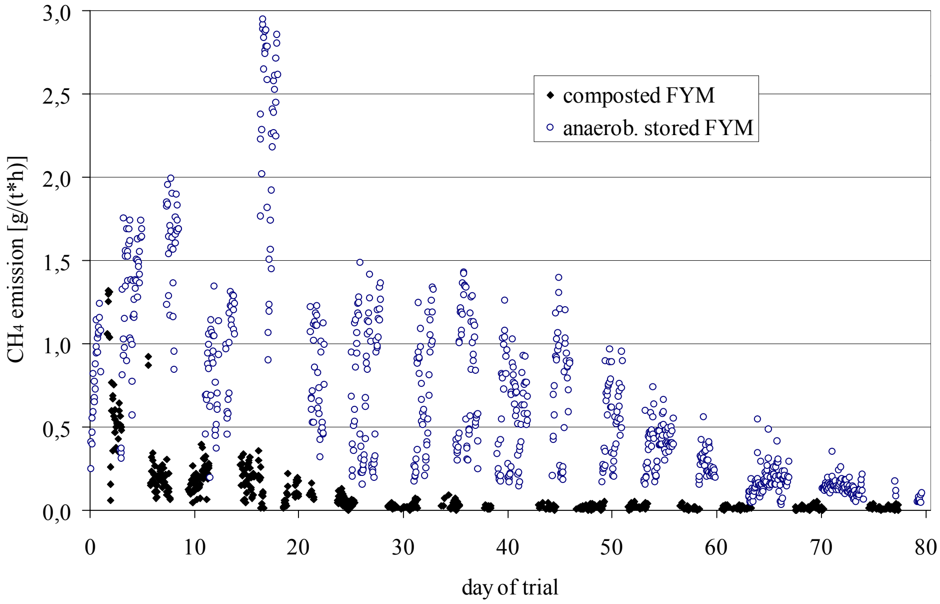

Figure 2.
Course of CH_4 emissions from composted and anaerobically stored FYM (summer)

As a part of the N emissions is lost via the seepage water, the seepage water should be collected. Most of the liquid N losses emitted at the beginning of the storage. Therefore farmyard manure should at least in the beginning be stored on concrete slabs with the possibility of collecting the seepage water. This would be an easy possibility to avoid a considerable part of the N losses during storage of farmyard manure.

In table 4 the sum of greenhouse gas emissions from composted and anaerobically stored solid manure are shown. To compare the global warming potential of the two treatments, N_2O and CH_4 emissions are given in CO_2 equivalents, that means relative to the global warming potential of CO_2 (EK 1995).

	Greenhouse gas emissions [kg CO_2 equiv./t FM[a]]		
	N_2O emissions	CH_4 emissions	*Sum*
composted FYM (su)	8.87	4.96	*13.83*
anaerobically stored FYM (su)	13.65	47.85	*61.49*
composted FYM (wi)	12.27	24.21	*36.48*
anaerobically stored FYM (wi)	20.64	18.41	*39.05*

[a] FM = fresh matter

Table 4.
Greenhouse gas emissions of composted and anaerobically stored farmyard manure

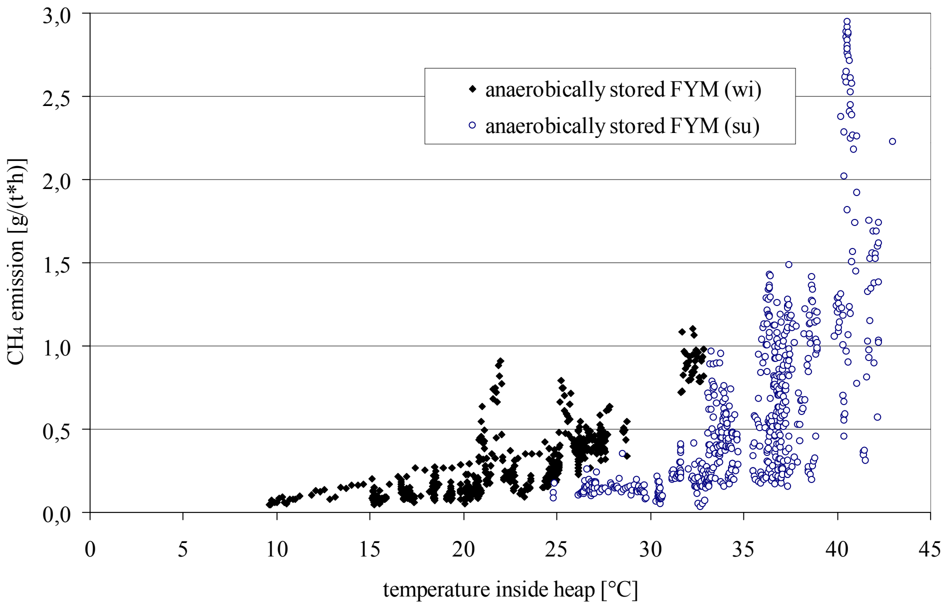

Figure 3.
Dependency of CH_4 emissions from anaerobically stored FYM (su and wi) on the temperature inside the manure heap

Greenhouse gas emissions from the anaerobically stored FYM (su) were about 4.5 times higher than from the composted FYM (su). Methane emissions contributed about 78% to the total emissions. Methane is formed under anaerobic, warm conditions when degradable C is available. Conditions in the anaerobically stored FYM favoured methane production. In summer and winter trial methane emissions from the anaerobically stored FYM were observed during the whole storage period and had not come to their end by the end of storage. They were strongly dependent on the temperature inside the manure heap (fig. 3). As the temperatures in the winter FYM rose only at the end of the storage, methane emissions were lower than from anaerobically stored FYM in summer. But they should have become much higher if the storage had continued longer.

Due to the lack of oxygen supply in the winter compost, N_2O and CH_4 emissions were higher than from the summer compost. A sufficient aeration is essential for a good composting process. Insufficient oxygen supply leads to formation of greenhouse gases.

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