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Emission of methane and nitrous oxide from livestock housing – a literature study

The greenhouse gases methane (CH4) and nitrous oxide (N2O) contribute to global warming. Methane emissions from livestock production are, to a great extent, endogenous. Nitrous oxide, on the other hand, is mainly produced and released through the storage and handing of livestock excrement and after its spreading. The literature shows that only a very limited usable amount of exact data is available on emissions of these gases. On cattle production, most of the data concerns methane emissions, for pig production most concerns nitrous oxide.

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Anthropogenetical activities, e.g., farming have led to an increase in the emissions from methane and nitrous oxide and, finally, to the increase in global warming. The global warming potential (GWP) of methane is estimated at 20 times [1], and of nitrous oxide, 300 times [2] that of the GWP for carbon dioxide (values based on mass and a time horizon of 100 years). Additionally, the N2O emissions lead to a reduction of ozone in the stratosphere caused by the stratospheric transformation of N2O to NO [2].

This report presents the results of literature research on the emission rates of nitrous oxide and methane from different types of livestock and housing systems. The following emission rates stem in the main from German and Dutch investigations.

In the full-length report (see LANDTECHNIK-NET.com) the development process of, and the influence factors on, the release of methane and nitrous oxide, the criteria which has to be followed for a scientific investigation and collection from emissions data, descriptions and data on methane and nitrous oxide emissions in storage are all collated.

Cattle production

In table 1 the measured methane emissions from cattle housing are collated, whereby the emissions originate both from the animals and from the excrement stored in the housing.

The data in table 1 show that the methane emissions from cattle housing vary between 120 and 390 g/GV and day with slightly higher values for dairy cattle in cubicle housing. The range of the data is comparable with the range of the methane emissions which are used as the standard in the Netherlands for dairy cattle of from 63 to 102 kg/year and animal (this represents 173 to 279g/day and animal) [9]. The highest methane emissions appear in connection with the feeding [10] The emissions level is in the main determined through the animal weight, the feed composition, and the milk production performance as well as the design of the respective housing (ventilation, type of flooring, type and dimensions of manure withdrawal and storage of excrement). The many influ-

Housing system	Emission	Remarks	Source
Dairy cows in byre	327	Emissions only from livestock	[3]
	120	four 24-hour measurements in summer and winter, emissions from livestock and excrement, volume-flow measurements via CO2 balance	[4]
	194	For slurry and solid manure systems	[5]
Dairy cows in cubicle house	320	Emissions from livestock and excrement, Average 12 days in April, Volume flow measurements with tracer gas.	[6]
	265	see above	[4]
	200 bis 250	Emissions from livestock and excrement measuring over one year, volume-flow measurements with measuring fans	[7] [8]
	267 bis 390	Emissions from animals and excrement Volume flow measurements with tracergas, Point measurements	
Feeding bulls on slatted flooring	147	see above	[4]
Feeding calves f slatted flooring	121	see above	[4] on

Table 1: CH_4-emission (g per livestock unit (lu) and day = g lu^{-1} d^{-1}) from cattle keeping

Housing system	Emission	Remarks	Source
Byre	0,62	Annual average; annual periodical influence	[5]
Deep litter bedding)	2,01	Summer measurements	[5]
Cubicle house	1,6	Average from 18	[7]
	0,8	measurements	[´6]

Table 2: N_2O oxide emmision (g lu^{-1} d^{-1}) from cattle keeping

Livestock type/ production system	CH_4	N_2O	Source
Feeding pigs on fully slatted flooring	2,8 to 4,5	0,15	[12]
		0,02 to 0,04	[13]
		0,15	[4]
Feeding pigs on partly slatted flooring	4,2	0,02	[6]
	11,1		[4]
Feeding pigs (strawless system, slurry)	1,5 to 3	-	[15]
	-	0,15	[16]
	-	0,31	[17]
Feeding pigs on deep litter/compost	-	1,9 to 2,4	[18]
	-	2,48 to 3,73	[19]
	-	0,59 to 3,44	[20]
	-	1,55 to 3,07	[12]
	-	1,43 to1,89	[13]
	-	1,09	[16]
Feeding pigs on straw	-	0,05	[12]
Feeding pigs on sloping floor solid dung system	0,9 bis 1,1	-	[14]
Sows	21,1	-	[4]
Piglets	3,9	-	[4]

Table 3: CH_4- and N_2O-emmisions (kg per animal's place and Year) in pig keeping

ence factors make it clear that realistic standard values for the calculation of methane emissions (in national studies or emission registers) along with different housing systems also should take into account a differentiating according to the already mentioned influence factors.

The data regarding nitrous oxide emissions from cattle production (table 2) are extremely limited which is mainly due to difficulties in the exact determination of air exchange rates in naturally-ventilated housing, the high time and labour expense, and the very low N2O concentrations (measurement ranges and solution limits of sensors).

It is reported in [5] that with nitrous oxide emissions no difference could be determined between byre (cowhouse) housing with solid and liquid manure. Where temperatures were higher, rising N2O emissions characterised deep litter bedding systems. Only deep litter systems with straw appeared to produce amounts of nitrous oxide worth mentioning, which is caused by nitrification and denitrification. Contrary to this, liquid manure systems produce no, or only very little, N2O in that liquid manure as a rule contains neither nitrate or nitrite which can be degraded through nitrification in anaerobic conditions [11]. [6] also reports on very low N2O emissions in the lower measuring scales of the sensors applied.

Pig production

In pig production, many investigations into the production of greenhouse gases have already been carried out (table 3). Similar to the deep litter system for cattle, only with pigs on deep litter and compost systems is production of nitrous oxide amounts worth mentioning determined. On the other hand, methane is released from all pig production systems. Here, the main source of methane release is the excrement stored within the housing. However, also the share of the methane released by the animals themselves should not be ignored in that this can represent up to 8 l CH4 per pig and day [15]. The amount of methane emissions from feeding pig production is influenced by feed composition (digestibility), and by the daily liveweight gain of the animals as well as the temperature and type of production system [15,11]. The data in table three show a substantial scatter. In the case of methane this scatter is caused mainly through the different types of animals and the various production systems. The methane emission from feeding pigs lies between 1.5 and 11.1 kg/pig place and year, whereby emissions of 21.1 kg per pig place and year for sows and 3.9 kg for piglets were able to be determined.

The range in nitrous oxide emissions can be traced back to the type of production system. Feeding pigs on fully or partly slatted flooring (liquid manure systems) emit only a very small portion of N2O (0.02 to 0.31 kg/animal place/year), whereas in deep litter and compost systems larger amounts (1.09 to 3.73 kg/animal place/year) are released [19]. Currently, no secure data are available for sows and rearing piglets.

Poultry production

The methane and nitrous oxide emissions from laying hen production (table 4) vary very strongly and can be looked upon very critically because the measured concentrations lie extremely low (only slightly over the background concentration of nitrous oxide). Basically, it appears that on-floor systems for layers cause higher emissions than cage or aviary production which is caused in the main by the litter materials (shavings, straw).Up until now, no secure data is available on methane and nitrous oxide emissions from broiler, turkey or duck production or from production systems with natural ventilation (Louisiana housing).

In comparison to the emission rates from cattle and pig production, values from the poultry sector are low. This has its origin in the much smaller bodyweights involved. With an arbitrary weight of 2.5 kg per layer, a GV would represent around 200 birds and the value from this determined by [23] would lie at around 0.042 kg per bird place and year.

Summary

In the literature, very few exact data on emission rates of methane and nitrous oxide in the livestock production sector are to be found. The data collated here shows an in-part substantial scatter of results which, in the main, has its origins in the multiplicity of influential factors on the amount of methane and nitrous oxide released, as well as well as the difficulties involved in accurate measuring.

Livestock/production system	CH_4	N_2o	Source
Laying hens, on- floor system, straw	0,076	0,,017	[22]
Layers, on-floor system, shavings	0,254 to0,383	0,043 to 0,079	[22]
Layers, on-floor system, 3/4 straw and 1/4 shavings	0,34	0,155	[22]
Layers, battery system/ aviary	-	0,95 gh^{-1} LU^{-1}	[23]
Layers, battery system/ aviary	not measurable	0,02 to 0,15 gh^{-1} LU^{-1}	[24]
Layers, battery system	0,06	-	[4]
Layers, on-floor system	not measurable	0,05 to 0,35 gh^{-1} LU^{-1}	[4]
Layers/free range	0,06	-	[4]
Broilers, on-floor system	0,02	-	[4]

Table 4: CH_4 and N_2O-emmisions (kg per animal's place and Year) in poultry keeping

Literature

Books are fignified with •

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