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Do ammonia emission rates from forced ventilated barns in pig fattening and piglet rearing need to be reviewed?

Jochen Hahne

Evaluations of a total of 641 on-site measurements by recognized testing centres in the period from 2020 to 2022 at pig fattening facilities showed an emission rate of at least 3.3 kg AP^{-1} a^{-1} for ammonia – measured with test tubes – with an average animal weight of 77.6 kg (SD = 22.1 kg) and year-round occupancy, even taking into account various measurement uncertainties. The respective monthly mean values for the ammonia concentration in pig fattening varied between 11.5 ppm in August and 15.4 ppm in February and for the barn temperature between 19.0 °C in February and 24.9 °C in July. The monthly average specific air rates varied between 36.5 m^3 AP^{-1} h^{-1} in January and 78.4 m^3 AP^{-1} h^{-1} in August. An alternative determination of the NH_3 emission rate via the blowdown of properly operated exhaust air purification systems yielded a comparable value of 3.5 kg AP^{-1} a^{-1}.

Corresponding evaluations of 179 on-site measurements at piglet rearing facilities in the period from 2019 to 2023 showed an NH_3 emission rate of at least 1.1 kg AP^{-1} a^{-1} with an average animal weight of 18.1 kg (SD = 6.5 kg) and year-round occupancy. The respective monthly mean values for the ammonia concentration in piglet rearing ranged from 6.6 ppm in January to 13.3 ppm in April and for the barn temperature between 20.7 °C in February and 26.0 °C in July. The monthly average specific air rates varied between 15.6 m^3 AP^{-1} h^{-1} in January and 29.9 m^3 AP^{-1} h^{-1} in August. The alternative determination of the NH_3 emission rate via blowdown of properly operated exhaust air purification systems yielded a value of 0.7 kg AP^{-1} a^{-1}.

Keywords
Ammonia, test tubes, emission rate, pig fattening, piglet rearing

Emission rates are important for the approval of livestock facilities and for the assessment of potential environmental impacts. The emission rates for ammonia that will apply in the future are set out in the current TA Luft (TA Luft 2021). The previous reference value for pig fattening (forced ventilation, slurry method) is 3.64 kg NH_3 AP^{-1} a^{-1} and for piglet rearing 0.50 kg NH_3 AP^{-1} a^{-1}. These figures correspond to the information in VDI 3894 from 2011 (VDI 2011). The data are again taken from a publication from 2002 (Federal Environment Agency 2002a). With regard to the emission rate for piglet rearing, the VDI guideline also states that the data still need to be validated, with reference to UBA texts 75 (2002).

In the last 20 years, the performance in pig fattening has increased significantly. According to the Rheinischer Erzeugerring für Mastschweine e.V. (2020), the daily gains increased from 722 g

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live mass (LM) animal^{-1} d^{-1} in the 2004/2005 survey year to 860 g LM animal^{-1} d^{-1} in the 2019/2020 recording period. At the same time, feed conversion was improved over the same period.

Feed consumption has fallen from 3 kg of feed per kg of live mass gain to 2.7 kg of feed per live mass increase. For the balance period 2020/2021, a daily live weight increases of 868 g LM d^{-1} and a feed consumption of 2.56 kg feed kg^{-1} LM^{-1} were reported (Waldeyer et al. 2021). Animal losses amounted to 1.14%. On the other hand, UBA Texts 75 (UBA 2002a), which were the basis for setting emission rates, used a daily increase of 700 g and a feed conversion rate of 3.0 kg kg^{-1} LM^{-1}. Animal losses were estimated at 3.4%.

The production figures and performance data in piglet rearing were given for the year 2020 by the Bundesinformationszentrum Landwirtschaft (2023). The daily live weight gain was 433 g LM d^{-1}, the feed conversion was 1.7 kg of feed kg^{-1} LM^{-1} with a rearing period of 54 days and a total of 6.2 passes per rearing site. With a rearing period of 54 days, an animal weight of 29.9 kg LM is achieved. The current values thus differ only slightly from the average figures in the UBA texts (UBA 2002a) with an estimated daily gain of 430 g LM d^{-1}, a feed conversion of 1.7 kg LM kg^{-1} feed^{-1} and 6.5 rotations per rearing site.

In view of the partially changed production figures, performance data and husbandry methods in pig farming as well as changed climatic conditions, the question arises as to whether the ammonia emission rates mentioned, which are now more than 20 years old, can still reflect the actual emission behavior sufficiently accurately.

The aim of this paper is therefore to estimate the ammonia emission rates from forced-ventilated barns for pig fattening and piglet rearing on the basis of data from on-site inspections by recognized testing bodies. The results were then checked for plausibility with an alternative determination of the NH_3 emission rates via the blowdown rate of the connected exhaust air purification systems.

Materials and Methods

In the period from October 2018 to March 2023, a total of 641 test reports from recognized testing bodies on forced ventilated pig fattening facilities and 179 test reports on forced ventilated piglet rearing facilities were evaluated with regard to NH_3 emissions on the day of the on-site measurement. During the on-site measurements, temperature, volume flow and the NH_3 concentration in the raw gas to the exhaust air purification system were measured. The ammonia concentration was measured once on site with test tubes. The reference pressure was 1013 mbar.

The conversion of the NH_3 concentration from ppm to mg m^{-3} was done according to equation 1.

$$\beta_i = (0{,}1 \cdot M \cdot p \cdot X_i) / (R \cdot T) \quad \text{(Eq. 1)}$$

β_i = NH_3 concentration in mg m^{-3}
M = Molar mass in g mol^{-1}
p = reference pressure in mbar
X_i = NH_3 concentration in ppm
R = Molar gas constant in kJ kmol^{-1}K^{-1}
T = Temperature in Kelvin
i = running index

The NH_3 mass flow in grams per animal per hour was then calculated according to equation 2. In principle, the number of animals on the day of the on-site measurement was used for the calculation and not the approved number of animal places.

$$q_m = (Q \cdot \beta_i) / (1000 \cdot AN) \qquad \text{(Eq. 2)}$$

q_m = NH_3 mass flow in g AP^{-1} h^{-1}
Q = Volume flow in m^3 h^{-1}
β_i = NH_3 concentration in mg m^{-3}
AN = Number of animals
i = running index

To convert to the calendar month, the value was multiplied by the hours of the respective month according to equation 2. For February, 672 h was always taken as a basis.

Determination of NH_3 emission rates after volume flow correction

Since the on-site tests were carried out during the day and the volume flow is lower at night due to lower outside temperatures, the NH_3 emission rate without volume flow correction would be systematically overestimated. Therefore, a corresponding volume flow correction was made. In the electronic operating logs, which were secured as part of the on-site inspections, the volume flows are documented every half hour. From these, the course of the volume flow for each day can be determined. Since the times of the on-site sampling are not known, the mean value of the volume flow from the period between 08:00 and 16:00 was assumed as the daily value and the average value from the period between 16:30 and 07:30 as the nighttime value. The average volume flows for the two periods have now been calculated individually from three electronic operating diaries for each calendar day and then combined into corresponding monthly means. The monthly means of each individual plant were then used to re-average. This approach resulted in corresponding correction factors for the volume flow measured during the day, which ranged from 0.83 in May to 0.98 in December. These correction factors were multiplied by the NH_3 emission rates determined by Equation 2 for each calendar month.

Estimation of measurement uncertainty

The accuracy of ammonia measurement with test tubes in the barn air is given as a coefficient of variation of 15 % (Bayerische Landesanstalt für Landwirtschaft 2014). According to Dräger, the standard deviation for ammonia measurement with short-term tubes is 10–15 % (Dräger 2021). The measurement uncertainties in the proper determination of flow velocity in ducts are given as approx. 5 % for thermal flow probes and approx. 2 % for impellers (Testo 2023). The individual standard deviations or coefficients of variation (15 % for the NH_3 measurement and 5 % for the measurement of the flow velocity) result in a measurement uncertainty or coefficient of variation of about 16 %.

Determination of the average emission rates from the blowdown of properly operated, biologically operating exhaust air purification systems

In addition to the procedure described in detail in this article for calculating the mean NH_3 emission rates from NH_3 concentrations and volume flows, these can also be determined from the blowdown rates of properly operated exhaust air purification systems, taking into account the average animal population. In the case of DLG-approved processes, an N separation of 70 % is guaranteed. The nitrogen is discharged from the exhaust air purification system with the washing water. The N concentration in the wash water of biologically operated exhaust air purification systems with a conductivity of 20 mS cm^{-1} is approx. 3.34 kg m^{-3}. Since the blowdown takes place continuously throughout the year, this data is highly informative.

The emission rate E is calculated according to equation 3:

$$E = (V_{ww} \cdot c_{ww}) / AN_m \quad \text{(Eq. 3)}$$

E = Emission rate in kg AP^{-1} a^{-1}
V_{ww} = washing water volume in m^3 a^{-1}
c_{ww} = N concentration in washing water (3.34 kg m^{-3})
AN_m = mean number of animals per year

For the conversion from nitrogen (N) to ammonia (NH_3), the result of equation 3 is multiplied by a factor of 1.216.

The determination of the emission rates via the blowdown is used to check the plausibility of the emission rates calculated on the basis of the ammonia concentrations in the barn exhaust air and the air volume flows.

Results on NH_3 emissions from forced ventilated pig fattening houses

The on-site measurements were carried out by various test centres during the day and throughout the year at pig fattening facilities of different sizes (Table 1). The mean NH_3 concentration was 12.8 ppm. In 15 cases (2.3 %), a value of more than 20 ppm was measured in the raw gas. The measured volume flows per animal place and hour resulted in a wide range of fluctuations with values of 2–147.8 m^3 AP^{-1} h^{-1}.

The average volume flow was 61.3 m^3 AP^{-1} h^{-1}. Values of more than 150 m^3 AP^{-1} h^{-1} were eliminated from the dataset because they are unrealistic and indicate manual intervention in the ventilation. The average animal weight was 77.6 kg.

Table 1: Results of the individual on-site measurements on the exhaust air composition of forced ventilated barns in pig fattening (n = 641)

Descriptive statistical parameters	Temperature, barn exhaust air °C	Number of occupied fattening places n	Live mass kg	Volume flow m^3 h^{-1}	NH_3 concentration, barn exhaust air ppm
Minimum	10.6	53	23	2,160	4
Maximum	32.9	4,350	130	279,936	30
Mean	22.7	1,043	77.6	62,993	12.8
Standard deviation	3.0	651	22.1	46,241	3.9
Median	22.8	921	75.0	51,840	13.0

The NH_3 mass flows calculated from the usable on-site measurement data showed a significant range of variation with values ranging from 0.01–1.47 g NH_3 AP^{-1} h^{-1}. On average for all usable measurements (n = 617), the emission mass flux for ammonia was 0.53 g NH_3 AP^{-1} h^{-1}

(SD = 0.27 g NH_3 AP^{-1} h^{-1}). This considerable range of variation is due to the fact that the measurements were carried out throughout the year, at different times of the day and also in different fattening phases.

For further evaluation, the usable individual measurements (n = 617) were sorted by calendar month and summarized into monthly averages (Figure 1). The calculation of monthly mean values for further evaluation was necessary because a comparable number of individual measurements was not available for all months of the year.

The figures below the columns shown in Figure 1 indicate the number of available and usable individual measurements for the respective month. The sorting of the measurements by calendar month showed that the highest monthly mean temperature of 24.9 °C occurred in July, while the highest average volume flow per animal place and hour was measured in August with 78.4 m^3 AP^{-1} h^{-1}. The highest mean NH_3 concentration occurred in February at 15.4 ppm.

Annual averages were then determined from the respective monthly averages. The annual mean values were 21.7 °C for the barn temperature, 13.4 ppm for the NH_3 concentration in the exhaust air and 55.2 m^3 AP^{-1} h^{-1} for the volume flow.

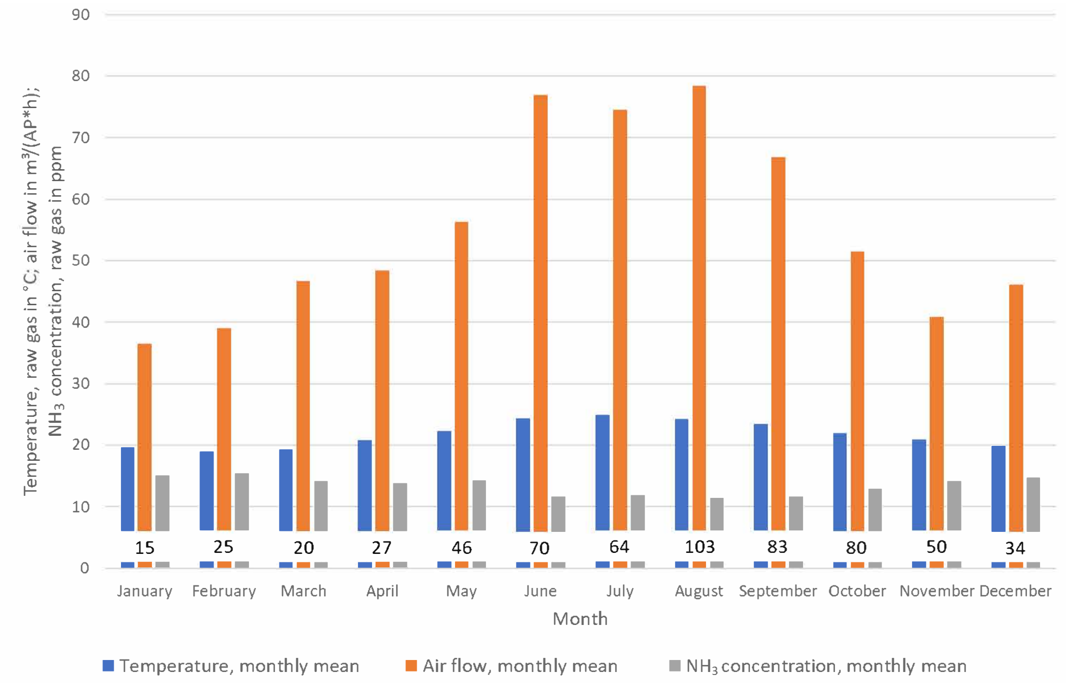

Figure 1: Seasonal course of the monthly mean values for raw gas temperature, volume flow and ammonia concentration in forced ventilated pig fattening houses (figures below the columns: number of individual measurements)

Figure 2 shows the NH_3 mass flows corrected for each calendar month. The highest mean NH_3 mass flow was recorded at around 401 g NH_3 AP^{-1} $month^{-1}$ in July, while the lowest value was recorded at around 260 g NH_3 AP^{-1} $month^{-1}$ in January. Based on the corrected average monthly data, the annual total is an NH_3 emission rate of approx. 3.9 kg NH_3 AP^{-1} a^{-1}, based on 365 days of husbandry (excluding service times). This value is 8% higher than the NH_3 emission rate, which is specified as 3.64 kg AP^{-1} a^{-1} in VDI Guideline 3894 (VDI 2011) for pig fattening in forced ventilated barns.

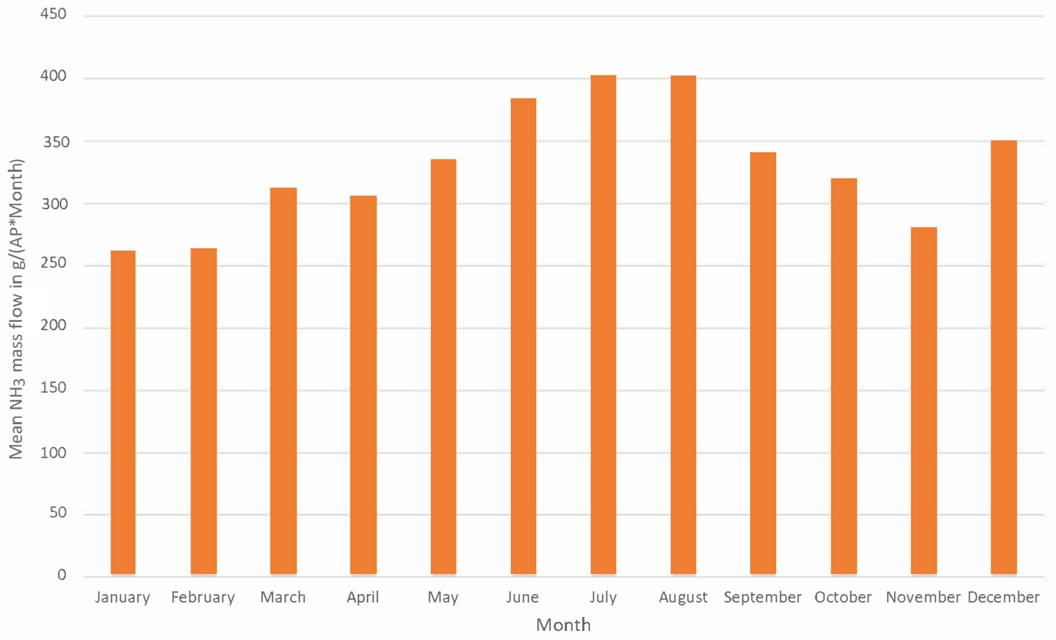

Figure 2: Mean monthly NH_3 mass flows in forced ventilated pig fattening houses

Results on NH_3 emission rates from forced ventilated piglet rearing houses

The on-site measurements were carried out by various test centres during the day and throughout the year at piglet rearing facilities of different sizes (Table 2). The mean NH_3 concentration was 8.4 ppm (SD = 3.4 ppm) and thus significantly lower than in the forced ventilated pig fattening facilities (Table 1). The measured volume flows per animal place and hour showed a wide range of fluctuations with values from 2.0 to 84.7 m^3 AP^{-1} h^{-1}. The average volume flow was 25.8 m^3 AP^{-1} h^{-1} (SD = 12.4 m^3 AP^{-1} h^{-1}). The average volume flow of forced ventilated piglet houses per animal place and hour was thus approx. 42 % of the average value of forced ventilated pig fattening houses.

Table 2: Results of the individual on-site measurements on the exhaust air composition of forced ventilated barns in piglet rearing (n = 179)

Descriptive statistical parameters	**Temperature, barn exhaust air °C**	**Number of piglet places occupied n**	**Volume flow m^3 h^{-1}**	**Live mass kg**	**NH_3 concentration, barn exhaust air ppm**
Minimum	16.0	444	3,133	5.0	3.0
Maximum	32.0	6,300	174,960	45.0	19.0
Mean	24.1	1,466	35,926	18.1	8.4
Standard deviation	2.6	997.4	26,108	6.5	3.4
Median	24.2	1134.5	32,400	18.0	8.0

The NH_3 emission mass fluxes, calculated from the usable on-site measurement data, showed a considerable range of variation with values ranging from 0.016 to 0.74 g NH_3 AP^{-1} h^{-1}. On average for all usable measurements (n = 174), the emission mass flux for NH_3 was 0.16 g NH_3 AP^{-1} h^{-1}

(SD = 0.09 g NH_3 AP^{-1} h^{-1}). This considerable variation is due to the fact that the measurements were carried out over the year and the day and at different animal weights.

For further evaluation, the usable individual measurements (n = 174) were sorted by calendar month and combined into monthly mean values, analogous to the evaluations of the forced ventilated pig fattening houses. The sorting of the measurements by calendar month showed that the highest monthly mean temperature of 26.0 °C occurred in July, while the highest average volume flow per animal place and hour was measured in August at 29.9 m^3 AP^{-1} h^{-1} (Figure 3). The highest mean NH_3 concentration occurred in April at 13.3 ppm. The lowest monthly average raw gas temperature was measured in December at 21.1 °C, while the lowest average volume flow rate of 15.6 m^3 AP^{-1} h^{-1} occurred in January. The average ammonia concentration in the barn exhaust air was also lowest in January at 6.6 ppm.

On the basis of the respective monthly averages, annual averages were calculated. The mean annual values were 23.7 °C for the barn temperature, 9.1 ppm for the NH_3 concentration in the exhaust air and 22.2 m^3 AP^{-1} h^{-1} for the volume flow with an average animal weight of 18.1 kg.

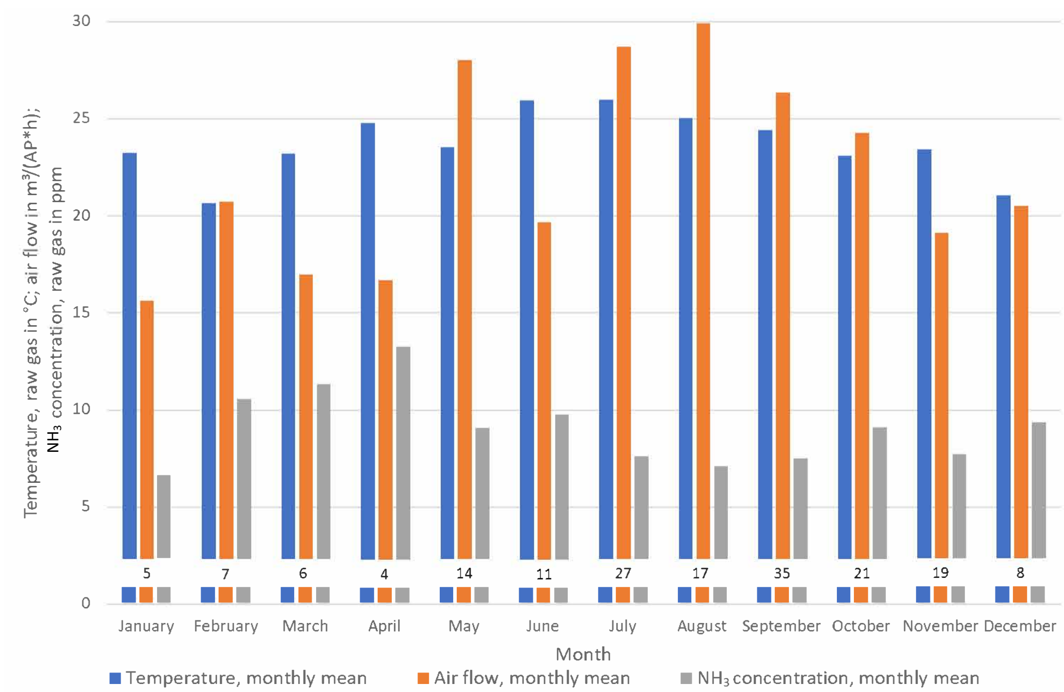

Figure 3: Seasonal course of the monthly mean values for raw gas temperature, volume flow and ammonia concentration in forced ventilated piglet rearing houses (figures below the columns: number of individual measurements)

Figure 4 shows the NH_3 emission mass flows for force-ventilated piglet rearing houses corrected for each calendar month. Trending, the corrected results showed the highest mean NH_3 emission rate at around 142.3 g NH_3 AP^{-1} $month^{-1}$ in October, while the lowest NH_3 emission rate at around 57.3 g NH_3 AP^{-1} $month^{-1}$ occurred in January.

The annual total is an NH_3 emission rate of approx. 1.3 kg NH_3 AP^{-1} a^{-1} for forced ventilated piglet rearing houses with year-round occupancy. The calculated value more than doubles the NH_3 emission rate for forced ventilated piglet rearing houses, which is specified in VDI Guideline 3894 (VDI 2011) at 0.50 kg NH_3 AP^{-1} a^{-1}.

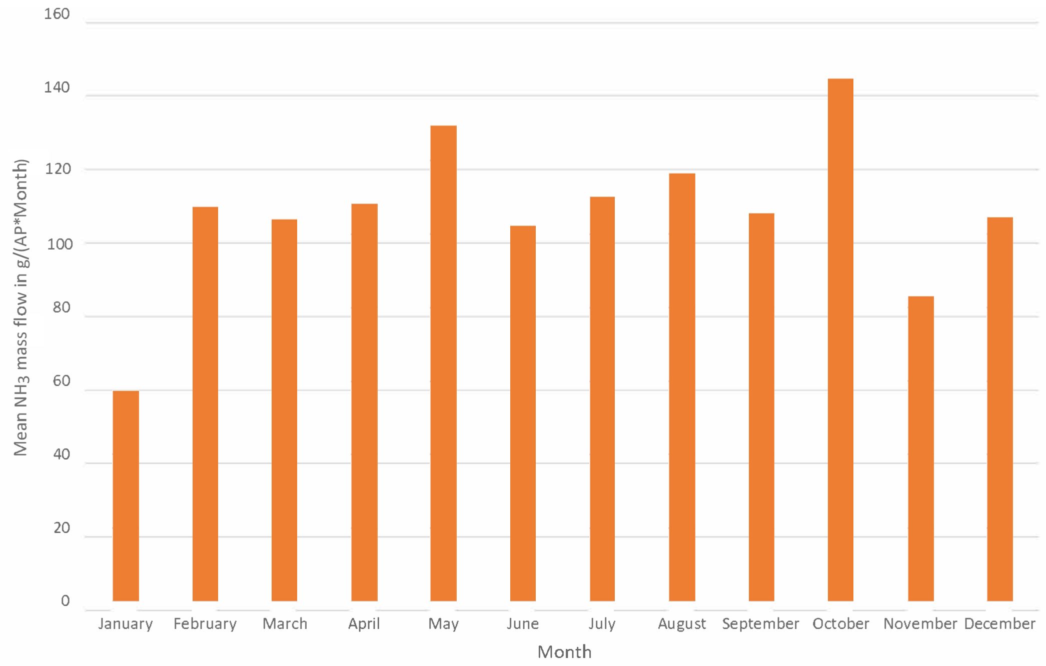

Figure 4: Mean monthly NH_3 mass flows in forced ventilated piglet rearing houses

Calculation of NH_3 mass flows via the blowdown rate of properly operated exhaust air purification systems

The blowdown rates of biologically operating and properly operated exhaust air purification plants are currently 0.61 m^3 AP^{-1} a^{-1} in pig fattening and 0.12 m^3 AP^{-1} a^{-1} in piglet rearing plants. Accordingly, 2.04 kg N AP^{-1} a^{-1} and 2.48 kg NH_3 AP^{-1} a^{-1} are discharged in pig fattening and 0.40 kg N AP^{-1} a^{-1} or 0.49 kg NH_3 AP^{-1} a^{-1} in piglet rearing.

Assuming an N separation of 70 %, rounded potential emission rates are 3.5 kg NH_3 AP^{-1} a^{-1} (pig fattening) and 0.7 kg NH_3 AP^{-1} a^{-1} in piglet rearing (Table 3).

Table 3: Comparison of NH_3 emission mass flows from forced ventilated pig fattening and piglet rearing facilities with year-round occupancy using different calculation methods

Calculation method	**Pig fattening** NH_3 **emission rate kg** AP^{-1} a^{-1}	**Piglet rearing** NH_3 **emission rate kg** AP^{-1} a^{-1}
Calculation of NH_3 concentration and corrected volume flow	3.9	1.3
Calculation of the blowdown rate with N-separation of 70 %	3.5	0.7

Discussion

On the basis of the described evaluation, an NH_3 emission rate of 3.9 kg NH_3 AP^{-1} a^{-1} was obtained for fattening pigs in forced ventilated barns. The evaluation is based on an extensive collection of punctual NH_3 measurements in the exhaust air flow as well as volume flow determinations carried out by renowned test laboratories. From these measurements, an average NH_3 concentration of 12.8 ppm (with a standard deviation of 3.9 ppm) was determined in the raw gas, based on 641 individual measurements. This value is consistent with other real-world results. Studies by the Bayerischen Landesanstalt für Landwirtschaft (2013a, 2013b), which dealt with the effects of N-reduced feeding, showed average NH_3 concentrations of 14.8 ppm in the barn air in summer. In winter, values between 17.7 and 24.5 ppm were detected. As part of suitability tests of exhaust air purification systems in pig farming, the NH_3 concentrations in the raw gas were continuously measured. The NH_3 concentrations ranged from 8 to 20 ppm (summer measurements) and 10 to 40 ppm for winter measurements (DLG 2014), between 6 and 27 ppm (summer measurements, DLG 2015; Reference farm 1) and 13 and 35 ppm (winter measurements, DLG-2015; Reference farm 1). In further DLG tests, NH_3 concentrations of approx. 4-20 ppm were found in the raw gas (DLG 2016, 2022).

During the measurements, monthly average volume flows of 36.5 (January) to 78.4 m^3 AP^{-1} h^{-1} (August) were determined. Based on the monthly averages, the annual average volume flow was 55.2 m^3 AP^{-1} h^{-1}. DIN 18910 (DIN 2017) provides for volume flows of 14.9 to 90.8 m^3 AP^{-1} h^{-1} for continuous fattening with an average animal mass of 70 kg. The calculated average volume flow of 55.2 m^3 AP^{-1} h^{-1} is only slightly above the average value of the mentioned range from DIN 18910 (DIN 2017). This may be due to the fact that the mean animal weight of 77.8 kg was higher in the measurements than the 70 kg used for continuous fattening.

When comparing these data, the increased average air rate in winter is particularly striking. There are several possible explanations for this. On the one hand, the Animal Welfare Farm Animal Husbandry Ordinance has been tightened to the effect that the NH_3 concentration in the barn may no longer exceed 20 ppm in the animals' living area. However, this used to be the case with low winter air rates. By increasing the minimum air rate, it is possible to avoid exceeding an NH_3 concentration of 20 ppm, especially in winter. On the other hand, the increase in animal performance has also led to increased heat production, which must be dissipated with the air flow. In general, it should also be noted that, statistically speaking, climate change leads to higher ambient temperatures (Umweltbundesamt 2022). For example, the annual mean daily temperature in Germany increased by 0.94 °C between 2002 and 2022. Since the barns are essentially cooled by air exchange, the cooling capacity decreases as ambient temperatures rise, with the consequence that the air exchange rate has to increase. An increasing air exchange rate can therefore be a cause of increasing NH_3 emissions.

For piglet rearing in forced-ventilated barns, the same procedure resulted in an NH_3 emission rate of 1.3 kg NH_3 AP^{-1} a^{-1}. The value is 2.6 times higher than the value given in the TA Luft (TA Luft 2021) for piglet rearing without strongly N-reduced feeding. The evaluation is based on a large number of punctual NH_3 measurements in the exhaust air flow and volume flow determinations. On the basis of these measurements, an average NH_3 concentration of 8.4 ppm (SD = 3.4 ppm) in the raw gas was determined for 179 individual determinations.

During the measurements, volume flows of 15.6 (January) to 29.9 m^3 AP^{-1} h^{-1} (August) were determined on a monthly average. Based on the monthly averages, an annual average volume flow of 22.2 m^3 AP^{-1} h^{-1} was determined. DIN 18910 (DIN 2017) provides for volume flows of 6.4 to 39.4 m^3 AP^{-1} h^{-1}

for piglet rearing and a weight of 20 kg. The calculated average volume flow of 22.2 m^3 AP^{-1} h^{-1} is almost in the middle of the range mentioned in DIN 18910 (DIN 2017).

The measurement uncertainty of the data from the on-site measurements can only be estimated. This is mainly due to the fact that neither the type of gauges used nor the number of individual measurements taken to determine the flow velocity are known. There is also a lack of information on the boundary conditions under which the measurements took place. A volume flow correction of the day data in relation to the night data was carried out on the basis of the data recorded every half hour in the electronic operating log. However, there is no correspondingly recorded data on ammonia concentration in the electronic farm diaries. In order to obtain an estimate of the significance of the NH_3 on-site determination in relation to the 24-hour average, data sets with half-hourly NH_3 concentration values were used, which were collected in the context of DLG tests of exhaust air purification systems (DLG 2015, 2016) in pig fattening.

From these data, the mean values of NH_3 concentrations in the period from 8:00 a.m. to 4:00 p.m. (daily value) and in the period from 4:30 p.m. to 07:30 a.m. (nighttime value) for summer conditions (n = 35 days) were calculated. According to these calculations, the daytime value was 9.2 ppm (SD = 2.0 ppm) and the nighttime value was 10.2 ppm (SD = 2.0 ppm). For winter conditions (n = 48 days), a daily value of 12.1 ppm (SD = 2.2 ppm) and a nighttime value of 12.0 ppm (SD = 2.3 ppm) were determined. It follows that the ammonia concentrations measured during the daytime during the on-site inspections are likely to be underestimated compared to the 24-hour average in summer. In contrast, the data collected in winter appear to be of a comparable magnitude to the 24-hour average.

Taking into account the measurement uncertainty (coefficient of variation) of 15.8 % in total, NH_3 emission rates of 3.3 to 4.5 kg AP^{-1} a^{-1} for pig fattening and 1.1 to 1.5 kg AP^{-1} a^{-1} for piglet rearing.

If the NH_3 emission rates, which have already been corrected for the volume flow error – 3.9 kg AP^{-1} a^{-1} for pig fattening and 1.3 kg AP^{-1} a^{-1} for piglet rearing – are adjusted downwards by an additional 15.8 % so as not to blame the operators for potential measurement errors, this results in an NH_3 emission rate of at least 3.3 kg NH_3 AP^{-1} a^{-1} for pig fattening. For piglet rearing, an adjusted rate of 1.1 kg NH_3 AP^{-1} a^{-1} is obtained.

Studies by Markus et al. (2023) on the NH_3 emission rates of fattening pigs have shown in four complete fattening cycles that a significant reduction in NH_3 emissions can be achieved via N-reduced feeding. Compared to the emission factor for manure-bound pig fattening from VDI 3894 (VDI 2011) with 3.64 kg AP^{-1} a^{-1}, the emission value above 3.31 kg AP^{-1} a^{-1} with N-reduced feeding fell to 2.56 kg AP^{-1} a^{-1} with very much reduced N feeding according to DLG leaflet 418 (DLG 2019). The NH_3 emission rate determined by our own evaluation for manure-bound fattening pig farming thus corresponds to the results of N-reduced feeding in farm practice.

Stocking density plays an important role in the assessment of ammonia emission rates. If this is reduced for reasons of animal welfare, such as in the case of the “stable + space” type of husbandry, while the emitting area of the barn remains the same, this leads to an increase in NH_3 emission rates related to the animal space. In view of the large number of new farming methods with different areas of land for the animals, the emitting area should therefore be included in the determination of the emission rate in the future. It is important to take into account that due to the formation of functional areas, the emitting area does not necessarily have to coincide with the floor area made available to the animals.

Conclusions

The evaluation of 641 test reports on forced-ventilated pig fattening facilities has shown that the average ammonia emission rate is currently at least 3.3 kg AP^{-1} a^{-1}. For this value, a correction of the volume flow (day-night differences) and a measurement uncertainty (coefficient of variation) of a total of 15.8 % have already been taken into account. An alternative calculation of the ammonia emission rate via blowdown – but without an assessment of the measurement uncertainty – results in a comparable emission value of 3.5 kg AP^{-1} a^{-1}.

The evaluation of 179 test reports on forced ventilated piglet-rearing facilities showed that the NH_3 emission rate is at least 1.1 kg of NH_3 AP^{-1} a^{-1}. For this value, too, a correction of the volume flow (day-night differences) and a measurement uncertainty (coefficient of variation) of a total of 15.8 % have already been taken into account. An alternative calculation of the ammonia emission rate via blowdown results in a lower value of 0.70 kg TP^{-1} a^{-1}, which is still significantly higher than the value of the TA Luft (TA Luft 2021).

In view of these results and the large number of new farming practices, a review of NH_3 emission rates in pig farming with forced ventilated houses is warranted.

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Author

Dr. Jochen Hahne is a research associate at the Thünen Institute of Agricultural Technology, Bundesallee 47, 38116 Braunschweig, Email: jochen.hahne@thuenen.de