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Exhaust air treatment for poultry facilities – only a partial success to date

Two different test facilities were operated over a period of eight month to clean exhaust air from two chicken stables. The exhaust air was initially cleaned by a dry working dust filter and subsequently scrubbed with an acidified washing solution. Volumetric flow, carbon dioxide, hydrogen sulfide as well as ammonia were measured quasi continuously. The particulate matter reduction was detected 45 times and the odor reduction three times over the measuring period. At filter loads between 2 300 and 2 600 $m^3/(m^2 \cdot h)$ an overall ammonia mass reduction up to 88 % was achieved, if the scrubbing was operated with a pH value below 5. The particulate matter reduction was 73 % (particle size range 1.3–1.6 µm) and 99 % (particle size range > 5.0 µm), respectively. In spite of a good ammonia and particulate matter reduction the calculated odor reduction was insufficient with 16–37 %. The typical odor perception from a chicken house could also not be eliminated.

Keywords

Exhaust air treatment, poultry farming, ammonia, particulate matter, odor

Abstract

Landtechnik 67(2012), no. 3, pp. 208–211, 4 figures, 3 tables, 9 references

The poultry keeping is an important and still growing economic factor in Germany. Based on data of the Federal Statistical Office in Germany [1] the poultry meat production increased from 822,716.7 tons in 2001 to 1,379,700.8 tons in 2010 (+68 %). In the same period the production of short fattening broilers rose about 91 % to 802,861.5 tons. The number of broilers increased from 59,221,711 (May 2007) up to 67,531,078 in May 2010 (+14 %) [2]. Also the number of laying hens raised about 27 % to 34 million heads since 2009 [3]. 23 from all in all 36.7 million poultry places fell upon the floor keeping in 2010. 67 % of it was kept in farms with more than 50,000 heads [1]. Besides high animal numbers on farm scale the poultry keeping is regionally concentrated. More than 12.5 million poultry places were located in Lower Saxony in 2010. North-Rhine Westphalia followed with 3.8 million poultry places by far [1]. About 30 % of the total German poultry stock was kept in the administrative districts of Vechta, Cloppenburg and Oldenburg. The per capita consumption of poultry meat increased from 1.2 kg in 1950 to 18.8 kg in 2007/2008 (+1567 %) [5]. Correspondent data for 2010 are stated with 19.3 kg [6]. An ongoing increase of poultry meat consumption can be supposed by the available data. This is caused by the facts that poultry meat is offered according to consumption and comparatively cheap as well. Beyond that it has a low fat content, is considered as useful for a balanced diet and is not banned with religious taboos.

Less information is available concerning the environmental effects of the poultry keeping and its considerable rising. The ammonia emission from the poultry keeping will increase to 71,000 tons per year in 2020 as prognoses show (+ 63 % compared to 1990) [7]. Also an increase of particulate matter emissions (PM_{10}) to 7,900 tons per year is predicted for the year 2020. Then the poultry keeping would create 36 % of the particulate matter emissions from the whole livestock in Germany [8]. In terms of odor emissions from poultry keeping different values are available in literature for animal categories and housing systems. For broilers, for instance, the odor emission factor showed a range between 60 and 170 odor units per 500 kg live weight and second [9]. At the end of a fattening period the odor emissions may exceed these values. The meaning of bio aerosol release from animal facilities and their environmental effect are currently investigated.

Proper techniques to clean exhaust air from poultry keepings are rarely available up to now. There is only one system approved by the German Agricultural Society (DLG). It can be used for the short fattening of broilers [4]. The system secured a total dust reduction of more than 72 % and an ammonia reduction of at least 70 % as well. But it offers no effective odor reduction.

Table 1

Measurement category and used analyzers for air and water determination

Parameter ***Parameter***	**Gerät** ***Measurement equipment***
Ammoniak/*Ammonia*	FT-IR Cx 4000, Ansyco, Karlsruhe
Kohlenstoffdioxid *Carbon dioxide*	FT-IR Cx 4000, Ansyco, Karlsruhe
Schwefelwasserstoff *Hydrogen sulphide*	Limas 11 AO 2020, ABB, Frankfurt
Volumenstrom/*Volume flow*	FLOWSICK 600, Reute
Temperatur/*Temperature*	Vaisala HUMICAP HMT 330, Helsinki
Gesamtstaub /*Total dust*	Sick FW 100, Reute
Partikelgröße/*Particle size*	Grimm 1.109, Ainring
Relative Feuchte *Relative humidity*	Vaisala HUMICAP HMT 330, Helsinki
pH-Wert/*pH value*	PRONOVA, Schott AL 90, Bad Klosterlausnitz
Leitfähigkeit/*Electric conductivity*	PRONOVA, LF 120201, Bad Klosterlausnitz

Against this background the development of proper techniques for poultry exhaust air cleaning becomes obvious.

Material and methods

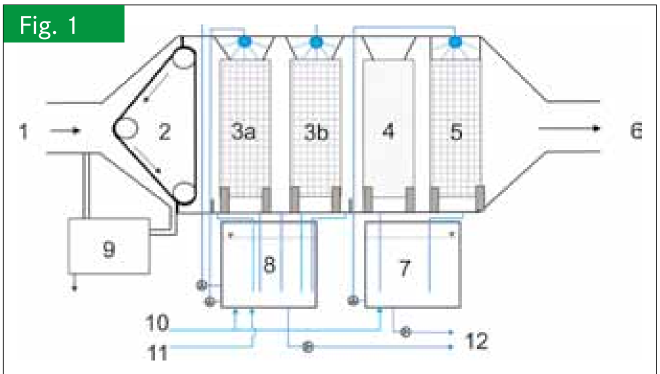
The tests for poultry exhaust air cleaning were operated at a chicken house (cocks and hens) in the period from May to December 2011. For the determination of waste air and water composition equipment shown in **Table 1** was used.

The olfactometry for the determination of the odor concentration was made by an accredited lab (Braunschweiger Umweltbiotechnologie GmbH).

Two different test facilities were used for the experiments (**Figures 1** and **2**). Both were operated with an almost identical and pressure controlled dust separation system as an initial treatment step. After dust separation an exhaust air scrubbing with different acidified washing solutions for ammonia reduction was carried out. The 150 mm washing walls were equipped with Raschig rings. Test facility 1 was operated with a pH value below 5 in the acidified washing solution, while the test facility 2 was operated with a pH value below 6 since August 2011. Two additional treatment steps were tested in test facility 1 – a easy degradable filter wall made of cottonwood and a final filter wall operated with water. The mean filter load was 2 320 $m^3/(m^2 h)$ (test facility 1) and 2 640 $m^3/(m^2 h)$ (facility 2). In both test facilities an irrigation density of 2 x 4 $m^3/(m^2 h)$ was used. The washing wall, operated with water, was only irrigated intermittently.

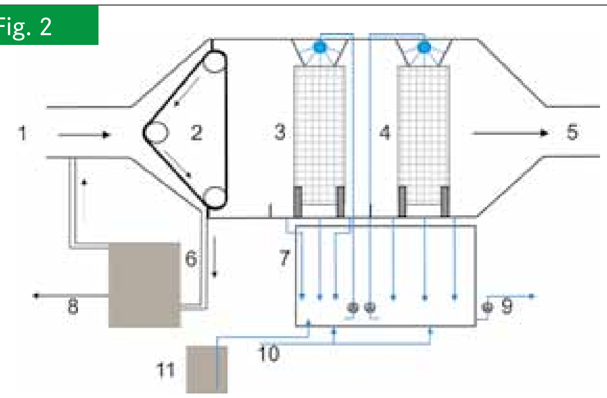
Exhaust air from chicken stable 1 was cleaned in test facility 1 and exhaust air from stable 2 was cleaned in test facility 2. The exhaust air composition from both stables is shown in **Table 2**.

Fig. 1



Test facility 1 for poultry exhaust air cleaning (1: raw gas, 2: dust filter with reclaimable filter pad, 3a: scrubbing unit 1, 3b: scrubbing unit 2, 4: odor reduction unit, 5: scrubbing unit 3, 6: clean gas, 7: reservoir 2, 8: reservoir 1, 9: dust exhaustion and removal, 10: fresh water supply, 11: sulfuric acid supply, 12: waste water discharge)

Fig. 2



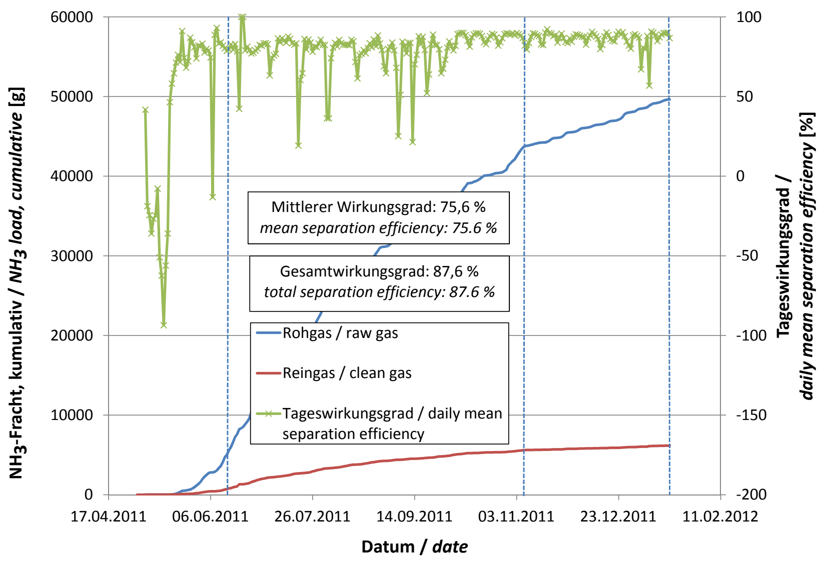
Test facility 2 for poultry exhaust air cleaning (1: raw gas, 2: dust filter with reclaimable filter pad, 3: scrubbing unit 1, 4: scrubbing unit 2, 5: clean gas, 6: filter pad exhaustion, 7: reservoir, 8: dust removal, 9: waste water discharge, 10: fresh water supply, 11: sulfuric acid supply)

Table 2

Raw gas compositions and range for the test facilities 1 and 2; daily means, total average in brackets

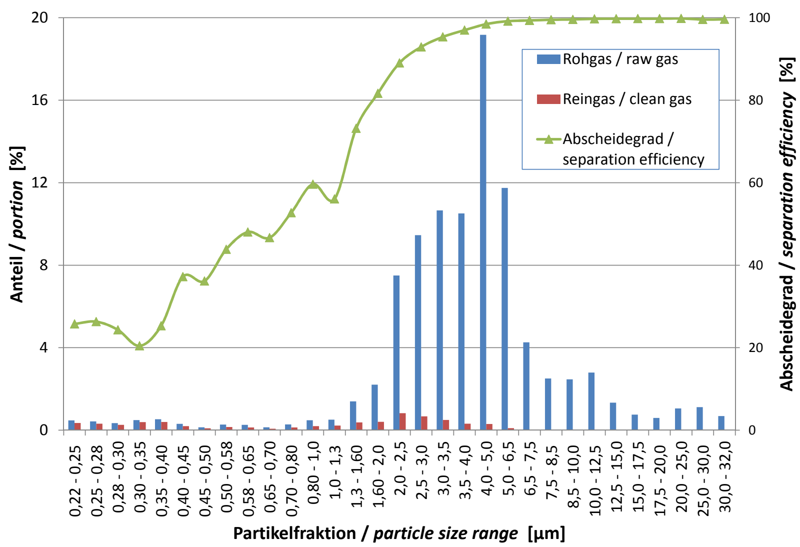
Rohgaszusammensetzung ***Raw gas composition***	**Versuchsanlage 1** ***Test facility 1*** **n = 210**	**Versuchsanlage 2** ***Test facility 2*** **n = 210**
Temperatur *Temperature* [°C]	17,4–25,8 (20,9)	19,1–28,6 (21,3)
Relative Feuchte *Relative humidity* [%]	32–78 (59)	36–78 (58)
Ammoniak *Ammonia* [ppm]	0,1–25,4 (4,3)	0,3–21,2 (4,2)
Gesamtstaub *Total dust* [mg/m³]	0,15–2,61 (0,77)	0,28–2,84 (0,80)
Kohlenstoffdioxid *Carbon dioxide* [ppm]	436–2 565 (1 022)	461–2 156 (975)
Schwefelwasserstoff *Hydrogen sulfide* [ppm]	0–2,1 (0,9)	0–2,9 (0,9)

Fig. 3



Ammonia separation by test facility 1

Fig. 4



Particle separation efficiency by test facility 1, means from 45 single measurements

Results

The raw gas ammonia concentrations from stable 1 varied considerably conditioned by ventilation control system and the dung removal intervals (0 – 25ppm).

Ammonia was separated with an overall efficiency of 87.6 % in test facility 1 (cumulative mass flow over the whole test period) (**Figure 3**). Lower efficient and short-term occurring values can be attributed particularly to time periods after a dung removal. At these periods the ammonia concentrations were less than 1 ppm in the raw gas. The broken lines in figure 4 showed days with odor sampling. The mean ammonia separation was only 75.6 % conditioned by these operation conditions.

In test facility 2, which was operated with a pH value below 6 not until August 2011, the mean ammonia reduction was only 32 %, while the overall ammonia reduction was 47.5 %.

The particulate matter reduction was only measured in test facility 1 (**Figure 4**). As expected, the 45 measurements showed an increase of separation efficiency with the particle diameter. While the mean separation efficiency was 73.2 % for a particle size range of 1.3–1.6 µm, it increased to more than 99 % for a particle size range of 5–6.5 µm. Particle size ranges between 2 and 6.5 µm are predominant in raw gas. In the cleaned air, however, particle sizes between 0.3 and 0.4 as well as 2 and 3.5 are relevant.

In spite of a considerable reduction of ammonia and particulate matter odor reduction of the test facilities was disappointing as **Table 3** shows. All in all three odor measurements were made by an accredited lab (Braunschweiger Umweltbiotechnologie GmbH). At conspicuous low odor concentrations in raw gas the calculated odor separation was only 16–34 % (facility 1) and 25–37 % (facility 2), respectively. An aggravating factor

Tab. 3

Odor reduction by test facilities

Versuchs-anlage *Test facility*	**Datum** *Date*	**Geruchskonzentration Rohgas [GE/m³]** [1)] *Odor concentration raw gas [OU/m³]* [1)]	**Geruchskonzentration Reingas [GE/m³]** *Odor concentration clean gas [OU/m³]*
1	14.6.2011	38	32
	7.11.2011	95	63
	16.1.2012	143	113
2	14.6.2011	38	24
	7.11.2011	107	76
	16.1.2012	135	101

[1)] GE: Geruchseinheit; Die Geruchsstoffkonzentration an der Wahrnehmungsschwelle beträgt per Definition 1 GE/m³/*OU: Odor unit; The odor concentration is 1 OU/m³ at the odor detection threshold by definition.*

is that the panelists nearly ever perceived raw gas odor in the exhaust gas during the measurements. The operation of the test facilities neither resulted in a relevant odor reduction nor in a reduction of the typical odor smell.

Conclusions

In spite of a good particulate matter and ammonia reduction it was not possible to achieve a satisfying odor reduction during poultry exhaust air cleaning. This is the result of long-term measurements with two different test facilities with filter loads between 2 300 and 2 700 m³/(m²•h). Also the typical odor smell of the raw gas could not be eliminated. The decisive odor components are obviously low in concentration, barely water soluble and not bound on particles as well. Therefore the development of other useful technologies for odor reduction in poultry keeping is urgent.

Literature

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