EXHAUST AIR TREATMENT SYSTEMS IN EUROPE

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INTRODUCTION

To comply with European emission threshold levels associated with animal husbandry, the emissions of ammonia, dust and/or odor has to be reduced significantly. Especially in regions with high animal densities the initial level of pollution already meets the set emission threshold levels in many cases. In these cases exhaust air treatment becomes a very appropriate measure to achieve a distinct emission reduction.

In Europe air purification systems are applied in general only at animal facilities designed with forced ventilation with locally defined air outlets, point sources respectively. For animal facilities with natural ventilation such as cattle and more and more poultry and pig stalls, where the air outlets are rather no point sources, normally no air treatment systems are employed.

Exhaust air treatment techniques applied at animal facilities for the "intensive rearing of poultry and pigs" are currently not ranked as BAT (Best Available Techniques) and hence are no part of the European reference document (BREF). At the same time, process technology has made good progress. In addition to classic biofilters and biological scrubbers (trickle bed reactors), chemical scrubbers and multistage treatment systems have established themselves especially in Germany.

Moreover, to support well designed and practicable air treatment systems in Germany, which achieve a defined minimum/average reduction performance, a testing procedure and certification called "SignumTest" was introduced in co-operation by a scientific expert group, the Association for Technology and Structures in Agriculture (KTBL) and the German Agricultural Society (DLG) Germany in 2006/2007. The SignumTest is by nature a utility value test. As the name implies, the test assesses the value of a product in practical testing, which is based on a test procedure devised by an impartial expert commission. The commission assesses the test results in accordance with fixed assessment standards and awards the DLG SignumTest symbol.

OVERVEIW OF AND REQUIREMENTS FOR AIR TREATMENT TECHNIQUES

At the present biofilters and biological scrubbers (trickle bed reactors), chemical scrubbers and multistage treatment systems are predominantly applied to treat the waste air from animal facilities with regard to the separation of total dust, ammonia, and/or odor. Table 1 gives an overview of air treatment systems currently used and on the main requirements to be met to achieve the German SignumTest award.

The use of single-stage biofilters for ammonia removal in animal housing is not recommended. Large quantities of enriched nitrogen lead to the formation of secondary trace gases and fast material decomposition so that the operation period of the filter material is shortened significantly. For odor reduction, however, they are very suitable.

For trickle bed reactors without pH-control, the required ammonia separation rate of 70 % is only reached at elutriation rates of ca. 0.2–0.3 m³ per kilogram of ammonia input. At the mentioned elutriation rate, scrubbing water regeneration is not required.

Chemical scrubbers provide little odor reduction because the low pH-value prevents the colonization of the filter walls by microorganisms. For this reason, they are not suitable for odor removal. In the clean air, the odor of waste air is regularly perceptible. Due to their very high ammonia separation capacity, chemical scrubbers are generally operated as two or three-stage installations and combined with trickle bed reactors or biofilters.

A two-stage installation consisting of a wet and a chemical scrubber also provides good odor reduction in pig housing. For poultry husbandry, currently no results are available. Two-stage installations are very suitable for dust reduction. Given the large total dust loads in littered housing, however, frequent treatment of the first process stage is indispensable. The treatment intervals should be determined and documented based on differential pressure measurements. The sprinkling density of the first stage should be considerably above the sprinkling density of the second stage. Like in trickle bed reactors, ammonia absorption capacity in the water stage of two stage installations is limited. In these systems, the combination of a water stage and a biofilter leads to ammonia being entrained into the biofilter. Only high elutriation rates (0.2–0.3 m³ per kilogram of ammonia input) allow good results to be achieved. However, this combination is very suitable for odor reduction and dust separation.

Table 1. Suitability of exhaust air treatment systems for forced ventilated animal housing facilities.

Treatment System	Utilization	Housing System	Assessment of Reduction Efficiency		
			Total Dust	Ammonia	Odor
Biofilter	pigs, cattle	not littered systems	+	n. g.	++
Biological Scrubber	pigs, cattle	not littered systems	+	+	+
Chemical Scrubber	pigs, cattle, dry poultry dung store	not littered systems	+	++	n. g
Multistage air treatment systems *two-stage*	pigs, cattle, poultry	littered and not littered systems			
• Wet Scrubber & Chemical Scrubber			++	++	0 / +
• Wet Scrubber & Biofilter			++	0 / +	++
• Chemical Scrubber & Biofilter			++	++	++
• Chemical Scrubber & Biological Scrubber			++	++	+
three-stage	pigs, cattle, poultry	littered and not littered systems			
• Wet Scrubber & Wet Scrubber & Biofilter			+++	+	++
• Wet Scrubber & Chemical Scrubber & Biofilter			+++	+++	+++

n. g.: unsuitable; 0: conditionally suitable; +: suitable; ++: good; +++: very good

Three-stage installations with two water stages and a biofilter stage are also only suitable for ammonia separation if they have such a high elutriation rate. As compared with two-stage systems in the same combination, however, they allow dust to be separated even better.

REMOVAL EFFICIENCY

With regard to odor reduction, certified trickle bed reactors and multiple-stage systems meet the criteria of the DLG SignumTest test frame (no waste air odor is perceptible in the clean air). For trickle bed reactors, this requires the observance of the described elutriation rates. Single-stage chemical scrubbers are not suitable for odor reduction because they do not fulfill the criteria of the test frame. Given appropriate design and operation, biofilters can also meet the criteria of the test frame. This requires that the filter material is kept sufficiently moist at any time. With the exception of the biofilter, all systems can be used for the reduction of ammonia emissions if they are designed properly even though their efficiency is different. Trickle bed reactors must also reach sufficient elutriation rates. All systems can meet the dust separation requirements for certification. In order to avoid the discharge of scrubbing water droplets into the environment, scrubbers must be equipped with a functioning drip separator at the outlet.

PROCESS CONTROL, DOCUMENTATION, AND MONITORING

DLG certified systems allow the decisive functional parameters, such as the pH-value, sprinkling density, and the elutriation rate, to be controlled efficiently. In agricultural biofilter systems, malfunctions are difficult to detect. This in particular applies to the drying of the filter material from the waste air side. In addition, there are few possibilities of intervention. Effective process control and monitoring require an electronic operations logbook where the decisive operational parameters, such as pressure loss in the exhaust air treatment system, the air flow rate, media consumption, and the pH-value, are recorded. In the case of a conflict, this enables the proper operation of the system to be documented.

COSTS

Virtually regardless of the technique and considering the cost degression provided by larger systems in pig fattening, total annual expenses in the amount of € 13 to 17 per animal place or € 5 to 6 per animal (without VAT) can be assumed as planning values for the construction and the operation of certified exhaust air treatment systems in combination with the new construction of an animal house. Based on a system capacity of 1,000 m³/h, total expenses in the amount of € 140 to 200 per year can be expected. In the relevant capacity range of 50,000 to 150,000 m³/h, cost degression is approximately 20 to 30 %. The costs include the most important factors which can be considered part of exhaust air treatment. They not only comprise the investment and operational expenses of the exhaust air treatment systems themselves, but also the additional requirements for housing ventilation as well as wastewater storage and spreading.

RECOMMENDATIONS

When planning an animal housing construction project with an exhaust air treatment unit, the owner must first consult advisers, experts, and the competent authority in order to find out which emissions of the animal housing facility cause problems in the neighborhood (odor, ammonia, and/or dust) and to what extent these emissions should be reduced.

In any case, it must be examined whether all possibilities of reducing the emissions by means of process-integrated measures in the animal house have been exhausted. These measures include optimized feeding and temperature control in the animal house, for example, or reductions at other sources, such as existing animal houses and slurry storage. In addition, it is necessary to determine whether the emission impact situation can be improved by means of better exhaust air conduction, e. g. in the form of a central exhaust air system. In a location analysis, a relocation of the construction project including a (partial) relocation of the farm to the outer area can also be examined as an alternative.

The choice of the treatment technique mainly depends on which emissions are intended to be reduced and which removal efficiency is necessary. In principle, only systems should be used which have been certified.

Measures for the reduction of the summer air flow rate, such as cooling, allow the dimensions of the exhaust air treatment system to be reduced and might lower the investment requirements and operational expenses significantly. Moreover, the operational expenses can be lowered if emissions are kept to a minimum by keeping animal houses dry and clean. If the air in the animal house is less polluted, fewer operating resources are consumed, and the service periods of the filters until the next treatment increases, which reduces the maintenance requirements. In addition, the flow resistance of the system and the electricity consumption are lower.

Several suppliers of certified exhaust air treatment systems should be asked to submit offers. The offers should contain the most important specifications for the proper design of the system. The offers should show the costs of the system and the expenses for the building shell as well as the specific expenses for the treatment of 1,000 m^3/h of exhaust air or per kilogram of ammonia separately so that the offers can be compared with regard to the prices.

In any case, reference systems should be visited and information from colleagues who operate similar systems should be obtained. Easily understandable, extensive system descriptions are also a sign of quality.

During planning and construction, the ventilation system of the animal house should be adapted to operation with an exhaust air treatment system. It should also be designed optimally with regard to air flow pattern, so that the filter surfaces are exposed to an even flow and the pressure loss, flow resistance respectively of the entire system is as low as possible. It is particularly important that sufficiently pressure-stable fans are used which can compensate the additional flow resistance of the exhaust air treatment systems of up to 150 Pa depending on the kind of system and the operating state. It must be guaranteed that the ventilation system can provide the required air flow rates with regard to animal welfare at any time.

In principle, the serviceability and the removal efficiency of the unit should be guaranteed in writing by the manufacturer. This also applies to the documentation which proves that the water protection regulations of the federal states and the work and chemical safety regulations are observed. After its construction, the system should be approved according to the requirements of the certification test. In general, a maintenance contract with the manufacturer is recommended. In addition, the owner should assume the responsibility for checking the system regularly (i.e. daily), and the system should be maintained no later than after the service intervals recommended by the manufacturer or in the test certificate. The operation of the system should also be monitored by the competent licensing authority.

The ammonium quantity contained in the wastewater should be considered in fertilizing management. The percentage of ammonium can easily be measured on the premises with the aid of quick tests. In scrubbers with an acid stage where sulfuric acid is used, the elutriated wastewater contaminated with ammonium sulfate must be stored in a separate container.

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