中德畜牧业合作项目

Virtual Study Tour on "Animal Manure Treatment and Utilisation in Germany" – Module 1 (from 7.4 to 8.4.2021)

Module 1

•Environmental and administrative aspects (fertilizing, water pollution and greenhouse gases)

Adaptation strategies and technologies for lower emission and exhaust air cleaning systems in pig husbandry

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Structure - Introduction

1. Pig industry: input - output - side effects
2. Impact on the environment
3. Reducing side effects
3.1 Input – output – ratio
3.2 General measures
3.3 Indoor technologies
3.4 End of pipe technologies
4. Layout data for 1.000 fattening pigs
5. Ranking and conclusion

Pig industry – input – output – side effects

Input:

animals – feedstuff – water – fresh air

- etc (bedding material, chemicals, medicines …)

Output:

MEAT

Side effects:

cadaver – faeces – urine (slurry, dung, litter) – exhaust air

Pig industry – side effects in the exhaust air

Exhaust air ingredients from different sources (animals, housing system):

Water vapour (a, h) (breathing: increased water content)

Energy (a, h)

1. increased output temperature [sensitive]
2. evaporation enthalpy [breathing, latent])

Carbon dioxide (a, h)

Smell (a, h): from dirty and damp surfaces

Ammonia (h): from urea by urease in faeces

[little nitrous gases, N_2O…, > bedding material]

Dust (a, h: animal activity, sources are dry bedding material, feed losses, pig bristles, dry organic material)

(total, PM_{10}, $PM_{2,5}$, bioaerosols, germs [zoonoses, general, animal health])

Others (h: methane, hydrogen sulphide [small content, highly corrosive],..)

Pig industry – impact on the environment from airborne pollutions

Smell from pigs

- People like to smell pigs only when they earn their money with them
  or meat is scarce
- Odour can be annoying and smell can be a nuisance but odour is not harmful to health

Ammonia

- Ammonia (NH_3) is the gaseous variant of ammonium (NH^{4+}). Ammonia and nitrate are fertilizers (farmland vs natural ecosystems)

Dust

- Dust includes organic material, organic material in the lungs could be a reason for asthma, people are often afraid of non-specific germs but there are no known cases of actual problems

Reducing side effects – **input-output-ratio**

Smell, ammonia and dust emissions

Fact: the emissions of odour, ammonia and dust are, within certain limits, emitted in a housing facility essentially not from the number of animals, but from the surfaces:

- Odour from all damp and dirty surfaces
- Ammonia from the manure surface (pigs in fully slatted housing systems are living on a sea of slurry)
- Dust from all dry surfaces

Consequence: The longer an animal stays in the barn to produce a quantity of meat (or piglets), the greater the load for odour, ammonia and dust per produced kg of meat (or piglet).

What to do to reduce emissions: <u>increase feed conversion and protein utilisation, reduce animal losses</u>.

Reducing side effects – general measures

Dry or

alternatively wet clean surfaces

and basically the greatest possible cleanliness

in the barn reduces emissions in general and reduces health problems for the animals and the people in the barn.

Sounds simple, and is also relatively easy to achieve, but is not being used everywhere and all times.

Reducing side effects – indoor technologies (1)

Protein-reduced feeding:

Adaptation to the actual amino acid requirements of the animals (in general more protein is fed than the animals need)

Advantage: reduced deamination in the liver, less energy consumption, reduced drinking water, reduced organ weights, less urine, reduced slurry quantity, better input-output-ratio, high potential, reduced ammonia content in the stable air and the exhaust air, better and healthier stable atmosphere for animals and staff - and the environment too

Disadvantage: dryer slurry could be a handling problem, the cost depends on the price of synthetic amino acids in relation to protein feeds

Reducing side effects – indoor technologies (2)

Faeces-urine separation:

Draining the urine before it mixes with the faeces: before the urea in the urine is split into ammonia by urease, it is stored separately from the faeces without the influence of stable air (examples PigT by Big Dutchman or special slatted floors or stable surfaces)

Advantage: high potential, reduced ammonia content in the stable air and the exhaust air, better and healthier atmosphere for environment, animals and staff

Disadvantage: technical effort, costs

Reducing side effects – indoor technologies (3)

Separation of functional areas in the pig pen:

Division of larger pens into lying area, feeding area and defecation area

Advantage: reduced faeces area, reduced ammonia content in the stable air and the exhaust air, better and healthier atmosphere for environment, animals and staff

Disadvantage: technical effort, costs, effects of animal behaviour (pictures left and right)

Reducing side effects – covering of slurry tanks (1)

Covering against wind influence and aerosol formation to reduce odour and ammonia emissions: **tent roof**

https://de.stefos.nl/silodach/?gclid=EAIaIQobChMIkPX1_vva7wIVg7h3Ch0IJABPEAAYASAAEgLJ6_D_BwE

1. Advantage: reduced water intake in humid climate, less liquid to handle, more than 90 % reduction of odor and ammonia emission, long lasting
2. Disadvantage: investment costs, handling, pay attention to UV stability, static requirements for the slurry tank

Reducing side effects – covering of slurry tanks (2)

Covering against wind influence and aerosol formation to reduce odour and ammonia emissions: **floating cover**

Left: www.guellewehr.de

middle: Raumberg-Gumpenstein LFZ A.Pöllinger

right: www.guellebehaelterabdeckung.de

Left: natural cover

middle: straw cover

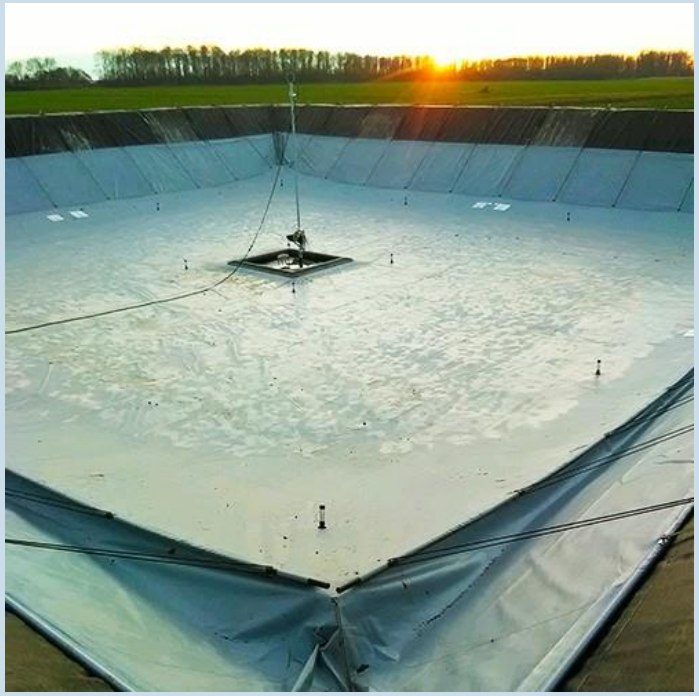
right: floating bodies

1. Advantage: ~ 80 % reduction of odor and ammonia emission, organic material (cheap: natural, straw), no static requirements for the slurry tank
2. Disadvantage: yearly handling of straw, no rain protection in humid climate, handling costs

Reducing side effects – covering of slurry tanks (3)

Slurry lagoons:

Picture H. Delfs



https://www.flexxolutions.nl/de/gullesack/

1. Advantage: cheap storage space
2. Disadvantage: large emission-active surface that varies depending on the filling level
3. Technical solution: slurry bag in the lagoon

End of pipe – air cleaning

Requirements and technical approach:

1. Central forced ventilation by fans necessary, no natural ventilation possible
2. Independent production branch with necessary process monitoring
   (similar to biogas plants)
3. Observe emergency ventilation in case of power failure to preserve the
   health of the animals
4. Investment costs are around 10% of the construction costs of the animal houses
5. Additional running costs are around 10 to 15 %
   (electric energy, water, management, maintenance)
6. Two steps of process:
   1. Adsorption of dust, odors and ammonia
   2. Biological oxidation of dust and odors to water and carbon dioxide and change of gaseous ammonia into solved ammonium

End of pipe – air cleaning systems (1)

Ultraviolet light: cold oxidation by free radicals and ozone

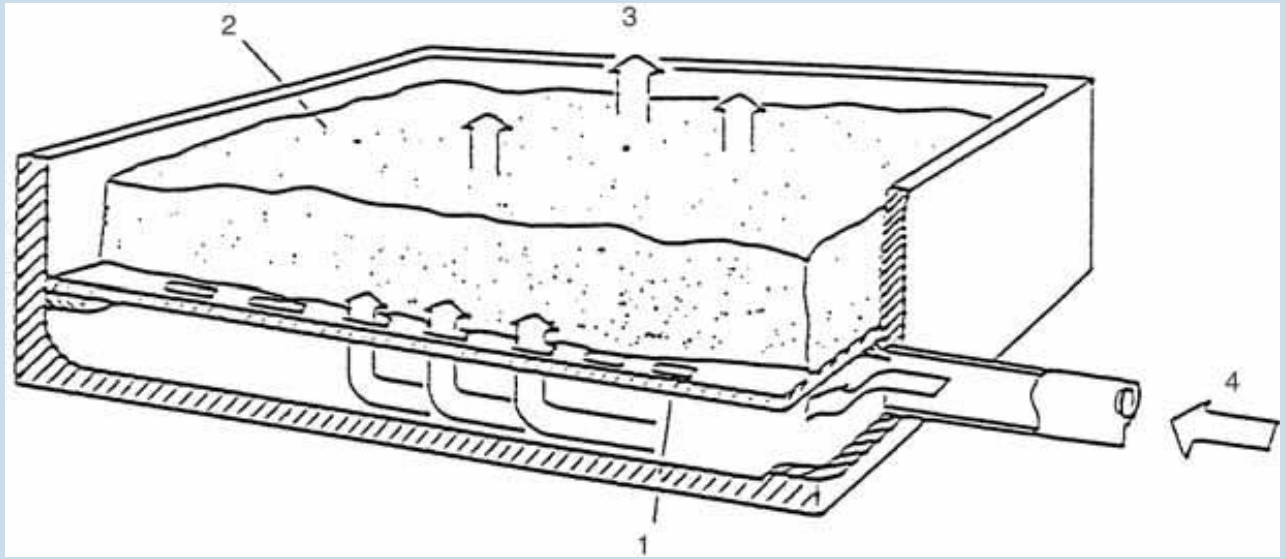
https://www.uviblox.com/de/abluftreinigung.html

Advantage: very clean system, plug and work, easy to manage

Disadvantage: only suitable in dust-free and non-corrosive atmosphere, high electric energy consumption, not suitable for animal husbandry

End of pipe – air cleaning systems (2)

Surface bio-filter:



VDI 3477

Schematic of a surface filter
1 Slotted concrete support for crude gas admission
2 Filter bed
3 Clean gas
4 Conditioned crude gas

Filter materials: straw/wood chips or cracked root wood

Advantage: very good cleaning performance for odor and dust, low back pressure

Disadvantage: sophisticated humidification necessary, installation space, yearly filter change, a good cleaning performance for ammonia only with perfect process control

End of pipe – air cleaning systems (3)

Air scrubber: chemical scrubber

Chemical scrubbers are exhaust air scrubbers or scrubbing stages in which the scrubbing water is controlled to a pH value between 3 and 5 by the addition of acid. Biological reactions such as the decomposition of odorous substances or the oxidation of ammonia to nitrite and nitrate (nitrification) practically do not take place. The basic design of a chemical scrubber corresponds to that of a trickle bed filter. However, in this case no alkalis are added and the wastewater generation is lower by a factor of 5 - 10. (DLG-leaflet 403, www.dlg.org)

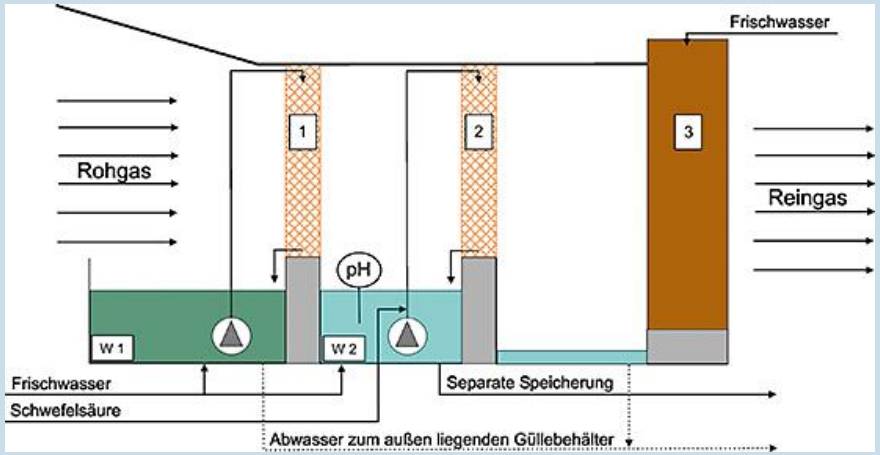
Advantage: very efficient ammonia separation and concentrating of wash water (less storage space, higher transportability)

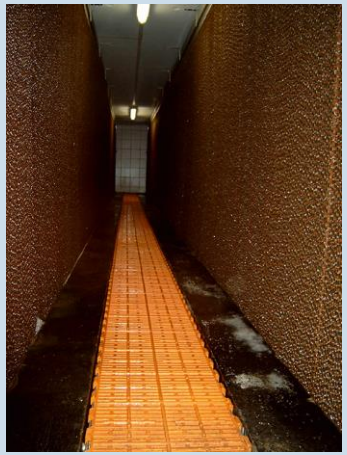
Disadvantage: storage of acid and washing water, which require increased expenditure due to their water hazard, must also be mentioned. The corrosion resistance of all plant components in contact with the media must be taken into account. “Clean air” smells like acids.

End of pipe – air cleaning systems (4)

Air scrubber: bio-trickling filter (1, 2 or 3 steps)

There is a wealth of single-stage or multi-stage combination processes. In recent years, new two-stage processes in particular have been developed. These usually work with a washing stage that is pH-controlled and a subsequent biofilter or a further washing stage. (DLG-leaflet 403, www.dlg.org)





Advantage: very efficient odor cleaning, dust and ammonia separation

Disadvantage: storage of washing water, back pressure, possibility of the formation of nitrous oxide, complex system, plant control, investment, running costs

Air cleaning – layout data for 1.000 fattening pigs

Database: DIN 18.910 (2017), VDI 3894.1 (2011)

Case: 1.000 fattening pigs, all in (30 kg bodyweight), all out (110 kg bodyweight)

Minimum ventilation rate - winter time, 30 kg: 8.200 $m^3\ h^{-1}$

Maximum ventilation rate - summer time, 110 kg: 98.200 $m^3\ h^{-1}$

Range for a air cleaner, used capacity: 8 – 100 % - high demands on the control technology

Emission per place per year: 3,64 kg ammonia, 0,6 kg dust

Cleaning performance: 80 % of ammonia, 80 % of dust

= 2.900 kg ammonia and 480 kg dust in the air cleaner

Reducing side effects – ranking and conclusion

1. Clean animal house
2. Protein reduced feeding, high digestibility of feedstuff
3. Reducing animal losses
4. Covering of slurry tanks
6. Exhaust air cleaning systems – bio-filters
7. Faeces-urine separation
8. Exhaust air cleaning systems – Scrubbers

Cost-effectiveness decreases with increasing technical effort,

a high mitigation performance causes a high technical effort.