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45 YEARS 1979-2024 AIR CONVENTION

Environmental and management techniques to reduce ammonia emissions Housing systems

The rate of ammonia volatilisation from floors is influenced by ambient temperature and air exchange rate. Controlling these factors will reduce ammonia emissions

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Ammonia emissions on dairy farms

Control the release of nitrogen from manures in livestock housing and slurry stores so that more can be retained as valuable fertiliser

Nitrogen in livestock manure

Ruminants are poor nitrogen converters, because only 5–30% of ingested nitrogen are up taken by the animal and the remaining 70–95% are excreted via feces and urine

Cattle slurry and farmyard manure (FYM) are made up of Organic N (e.g. proteins), ammonium N (readily available nitrogen) Some composted manures contain small amounts of nitrate

→ Organic Nitrogen This is the nitrogen bound in organic compounds within manure. It is not immediately available to plants and must first be broken down by soil microbes into ammonium (NH_4^+) and then into nitrate (NO_3^-).

→ Ammonium Nitrogen (NH_4^+) This form is readily available to plants but can easily be lost to the environment through volatilization, especially in warm conditions, if the manure is left on the surface

→ Nitrate Nitrogen (NO_3^-) This is the most plant-available form but is also highly mobile in soil and can leach into groundwater if not managed properly

→The higher the percentage of Total Ammonium N (TAN) the manure contains, the higher the potential of ammonia loss

Cattle slurry, and the liquid portion of separated cattle slurry, have a high TAN % (>30%), so there are high potential ammonia losses compared with cattle Farm Yard Manure (FYM) which typically has a 10–15 TAN % depending on the manure to straw ratio

→Carefully managing manures can improve ammonium nitrogen retention and reduce reliance on manufactured fertiliser

Good Practices Cattle housing

→Regularly wash and scrape floors

→Design floors to drain effectively so urine and slurry are not allowed to pool

→Frequently transfer slurry to a suitable store: Ensure grit and sediment are regularly removed from slurry channels and collection systems.

→ grooved floors with perforations can channel urine and improve drainage. Scrapings should occur at least twice daily.

→Reduce the surface area of the slatted area. Maximise the transfer of excreted material to channels

→ Solid floor areas should have provisions such as a slight slope to allow urine to drain to the channels

→ Channels should be emptied frequently by the use of scrapers (unless drain by gravity), a vacuum system or by flushing with water, untreated liquid manure (under 5% dry matter) or separated slurry

→Avoid ventilation directly above the surface of the slurry in the channels. Minimise the velocity of the air over the surface of the manure

→ Where this is unavoidable, the gap between the slats and the manure surface should be sufficiently large to minimise drafts across the surface

→Reduce the pH of the slurry (acidification)

→Increase the amount of straw used per animal for bedded systems Straw can soak up urine and help to keep floors dry, preventing pooling of urine

→ The appropriate amount of straw depends on the breed, feeding system, housing system and climate conditions

Reducing ammonia emissions in dairy housing

Ways to reduce ammonia emissions from manures

→Housing periods and frequent removal of manure
→Cattle house flooring
→Environmental and management techniques
→Emission factors data

Housing periods and frequent removal of manure

Reducing the housed period of cattle and regular removal of manure can both have a positive impact on ammonia emissions

→Only around 6% of the TAN (ammonia nitrogen content) from the manure produced when the cows are out grazing is emitted to the atmosphere as ammonia

→Significantly less compared with the average for slurry-based housed systems which is estimated to emit 28% of the TAN(average that can vary significantly depending on factors such as housing design and the frequency of scraping)

→Additional emissions are produced later in the slurry management cycle during storage and spreading, which does not occur when cattle are grazed

The grazing system - the most common one in Georgia

Increasing grazing is often limited by grassland available, soil type, topography, farm size and structure, climatic conditions, etc… (overgrazing due to poor grassland management/absence of fencing)

→Grazing animals may increase other forms of N pollution (e.g. nitrate leaching and nitrous oxide (N_2O) emissions by nitrification and denitrification processes strongly influenced by climate and soil factors

→Changing from a fully housed period to grazing for part of the day is less effective in reducing NH_3 emissions than switching to complete (24-hour) grazing since buildings and stores remain dirty and continue to emit NH_3

Methods that can be used to move slurry

Frequent cleaning of passages and yards will reduce the exposure of the slurry to the air and so reduce ammonia emissions

Studies have shown that increasing scraping from once a day to four times a day can reduce ammonia emissions by up to 20% by reducing the volume of slurry exposed to the air

There are several methods that can be used to move slurry to minimise its exposure to the air:

- →Automatic passage scrapers
- →Robotic scrapers
- →Washing scraped surface areas
- →Floor construction
  - →Low emission flooring
  - →Grooved floors
  - →Slatted floors

Butrana dairy demonstration farm, village Tibaani, Signagi municipality, Georgia,

Housing periods and frequent removal of manure

Automatic passage scrapers

→Effective way of ensuring passages are scraped regularly (every hour)

→provides a clean floor, reducing the risk of contamination of beds and animals.

→Maintaining drains and repairing broken or badly laid concrete will help prevent effluents from ponding and improve the effectiveness of scraping.

Robotic scrapers

→There are a range of scrapers available, but most will only work on a slatted floor system

→advantage over automatic passage scrapers as they can often reach more areas of the shed.

→Depending on the shed size, it may be necessary to have more than one robot to ensure all areas can be scraped every two hours whilst allowing charging time

Washing scraped surface areas

Washing scraped surface areas

Scraping with a rubber or steel scraper will leave residue and allow ammonia to be released.

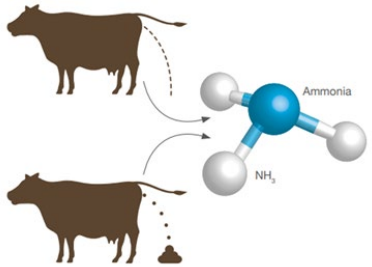
Studies have demonstrated that washing with water post scraping can result in a reduction of up to 70% of emissions, compared to scraping alone

→applicable to collecting yards, milking parlours, dispersal yards and cattle handling areas

→However, these options add to the volume of slurry that needs to be stored and spread

Floor construction

Ammonia is produced when the urease enzyme within animal faeces reacts with urea in urine, resulting in ammonia being volatilised



Floor construction

Options for emission reduction in livestock housing focus on the floors of the housing where the urine and faeces end up

→Floors that are designed to allow either rapid separation of the faeces and urine or the removal of the combined product (slurry) to an environment where gaseous exchanges are minimised, can effectively minimise emissions per cow

Low emission flooring

Low emission floor, which is sloped with a separate urine channel, used with a plastic or rubber scraper. This sloping floor profile is fitted with a gutter for urine under a 1.5% slope. This design allows the urine to drain away quickly, reducing its contact with the faeces, thus minimising ammonia emissions.

Floor construction

Grooved floors

→ grooved floor system also works using effective drainage

→ This system for dairy and beef cattle housing uses 'toothed' scrapers running over the grooves

→ Grooves can be perforated to allow even better separation of urine into storage below. This results in a clean, low-emission floor surface with good traction for cattle to prevent slipping.

→ Ammonia emission reduction ranges from 25% to 46% relative to the reference system

Slatted floors

→ A slatted floor with slurry storage beneath

→ Popular system in the Netherlands: <u>most work done on ammonia emission from cattle housing is based on this construction</u>

→ Slatted floor systems are less popular in other European countries (France, Denmark, UK)

→ Standard slatted floors rely solely on gravity and cow traffic to clean the slats of manure

→ Higher rate of ammonia emission reduction (40–60%) than a solid concrete floor which allows effective drainage and is regularly scraped (in this case the liquid will remain on the slats, increasing the volatilisation

Improvements

Unscraped yards, such as the one depicted are high-risk ammonia emitters

Environment and management technics

→ Controlled environment dairy housing
→ Slurry cooling
→ Reduced pH of slurry
→ Loose housing

Environment and management technics

Traditional slatted sheds

→ In cattle buildings with traditional slats, optimal shed climatisation with roof insulation and/or automatically controlled natural ventilation can achieve a moderate emission reduction (20%) due to the decreased temperature (especially in summer)

Air scrubbers

→ Chemical or acid air scrubbers, while effective in decreasing NH3 emissions from force-ventilated pig housing, cannot usually be installed in cattle housing which is mostly naturally ventilated

→ Air scrubbers can be incorporated with forced ventilation, but this requires a large capital investment as most cattle buildings are naturally ventilated

Environment and management technics

→ In addition to the concentration of urea in urine and the rate of air exchange, pH and temperature of the slurry are factors affecting volatilisation rates

Slurry cooling

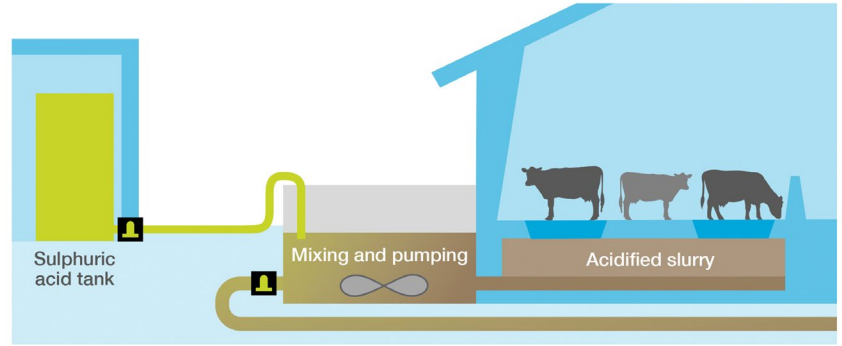
→ Cooling equipment can be installed in floors of cattle buildings or in slurry stores to reduce the temperature, and therefore reduce ammonia emissions

→ Most data on slurry cooling comes from work done with pigs in Denmark

Reduced pH of slurry

→ Lowering the pH of slurry stored under a slatted floor to 4.5 by adding sulphuric acid may resulted in a 37% reduction in ammonia emissions from cow slurry

- → However, the use of sulphuric acid has health and safety implications
- → requires significant capital investment and increases risks from poisonous gasses and foaming
- → Adding sulphuric acid to reduce pH is well documented in pig enterprises (widely used in Denmark)



Source: AHDB, UK

Good Practices Cattle housing

Loose housing

Housing cows in an open yard on deep straw can result in up to a 25% reduction in ammonia emissions per cow

→Straw can soak up urine and help to keep floors dry, preventing pooling of urine

→Increased bedding quantity and frequency also lower emissions

→However increased methane CH4 production from Farm Yard Manure compared with slurry

→The physical characteristics of bedding materials are of more importance than their chemical characteristics in determining NH_3 emissions from cattle shed floors

Increase the amount of straw used per animal for bedded systems

→The appropriate amount of straw depends on the breed, feeding system, housing system and climate conditions

(Some alternatives to straw: woodchip, peat bedding)

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Ammonia emissions on poultry farms

Poultry housing should be kept as dry as possible as poultry manure and litter emit more ammonia when wet

Consider available techniques for reducing ammonia emissions from your poultry housing, particularly when refurbishing or constructing new buildings

Ammonia in poultry systems

NH_3 emission influencial factors

- Housing systems and type
- Bedding material
- Litter moisture and pH

- Diurnal and seasonal variations
- Indoor temperature and relative humidity
- Ventilation system

- Diet
- Birds age, stocking density and diurnal activities

- Manure management

Emissions processes and influential factors in poultry houses

Floor-based poultry house (e.g., broilers or cage-free hen houses)

→Fresh poultry manure contains about 75% moisture, which may result in the loss of most manure nitrogen in the form of NH_3 gas in a short period if no mitigation strategies are applied

Effect of bedding, litter moisture, pH, and temperature

Litter quality changes with the change of bedding materials that are either organic (plant-based material like wood) or inorganic (stone, clay, and sand)

→The objective is to provide comfortable, nontoxic, and suitable moisture absorbent medium for chickens

Effect of pH on NH3 emissions

The pH of excreted poultry manure and litter is found between 7.5 and 8.5 (alkaline pH) on average, which is optimal for the NH3 production bacteria

→Lowering pH levels in manure or litter prohibits the decomposition of uric acid as urea and the conversion of ammonium into NH3 gas: the equilibrium ($NH_3 + H^+ \leftrightarrows NH_4^+$) shifts toward the less volatile NH_4^+ ion after acidification

→reducing the pH of poultry litter from 7 to 3 resulted in NH3 reduction of 60–80%

Feed nutrition contents

Broilers and layers in commercial houses are fed with high crude protein (CP) diet to meet their daily nutritional needs for growing and production (meat or eggs)

→Higher CP feed tends to result in increase nitrogen in manure and a higher NH3 emission, because undigested proteins and uric acid are primary NH_3 emission sources

Emissions processes and influential factors in poultry houses

Bird age, stocking density, and activities

→Ammonia production is affected by birds' density and a higher stocking density house results in higher moisture content of litter and NH3 emissions

Impacts on chickens' health and welfare and production efficiency

→High levels of NH_3 have negative impacts on animals' health and welfare.

→The primary harmful impacts of high concentrations of NH_3 in chicken houses include lower growth rates, reduced feed intake, reduced egg production, damaged air tract, and poor egg quality

Good Practices - Floor-based poultry housing

→Poultry housing should be kept as dry as possible as poultry manure and litter emit more ammonia when wet

→ regularly check building structure and water drinkers to reduce any leaks and keep litter dry. More ammonia will be emitted if the litter becomes wet and then dried.


source: JM Lescot


source: JM Lescot


source: JM Lescot


source: JM Lescot

Poultry manure


source: JM Lescot

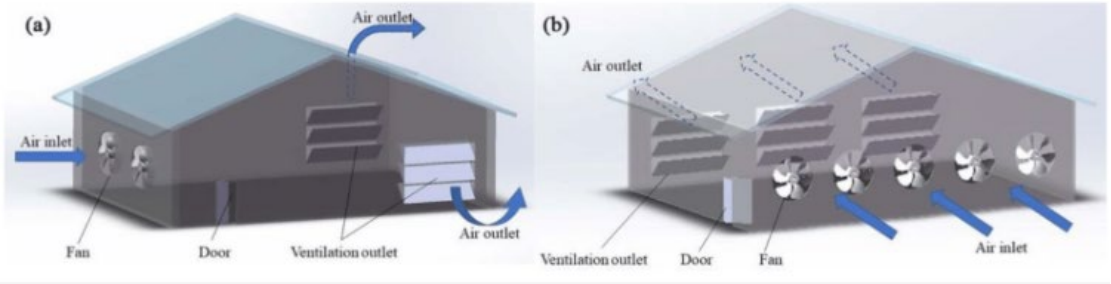
$$C_5H_4N_4O_3 + 3[O] + 4H_2O \longrightarrow 4HN_3 + 5CO_2$$

Process of NH3 production from poultry houses

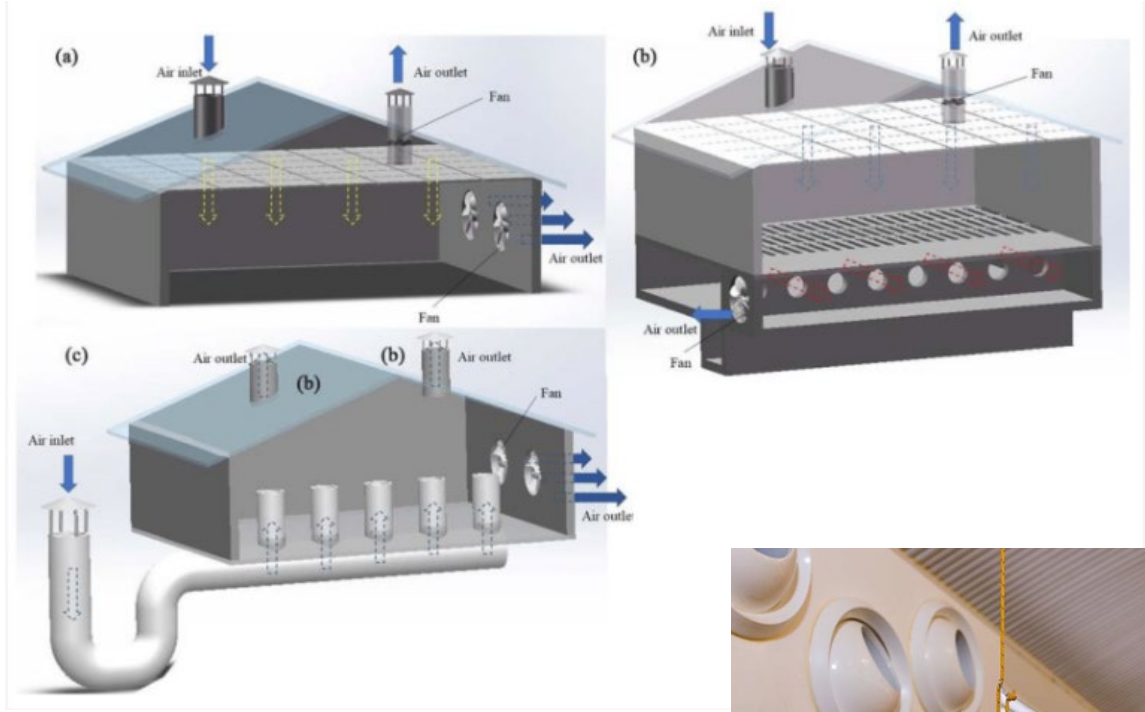
Good Practices - Floor-based poultry housing

Acid scrubbers or bio trickling filters can help remove ammonia from exhaust air

→ A multistage scrubber is recommended because of the co-benefits in reducing ammonia and other particulate emissions



mechanical longitudinal ventilation (a), and transverse ventilation (b)



ceiling ventilation (**a**), pit ventilation (**b**), and tunnel ventilation (**c**)

An air scrubber is an air-purification system that removes PM or other pollutants from the air by using moisture or filtering the airstream as it enters the scrubber. The data in the literature indicate that air scrubbers can effectively remove air pollutants in mechanically ventilated housing. They can be divided into three main groups—chemical, biological, and combined air scrubbers—as depicted in Figure 4. In chemical air scrubbers ('chemical ASs'), an acid is added to the washing water to decrease the pH (to 1.5–4), shifting the equilibrium towards ammonium and thereby increasing the absorption capacity, for which sulfuric acid (H2SO4) is typically used.

Source: Li Guo and al. Mitigation Strategies of Air Pollutants for Mechanical Ventilated Livestock and Poultry Housing—A Review, Atmosphere 2022, 13, 452. https://doi.org/10.3390/atmos13030452

Source: Zootecnica International Poultry Magazine

Good Practices - Layer housing

→Use a belt system to collect and remove manure

→ Collect and remove manure frequently with manure belt system to covered storage outside the building

→Intensively ventilated drying tunnels, inside or outside the building, can increase the dry matter content to 60%-80% in less than 48 hours.

Ammonia emissions become significant when the manure is one to two days old and increase rapidly at five days old

→therefore the removal frequency should be two or three times per week

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Ammonia emissions on pig farms

You can reduce ammonia emissions by reducing the exposed surface area of the waste and reducing the movement of air over the waste. Consider these techniques for reducing ammonia emissions from your pig housing, particularly when refurbishing or constructing new buildings

Ammonia in pig farming

NH_3 emission influencial factors

- The floor type
- Climatic conditions inside the building
- Diet composition
- Feed efficiency
- The manure removal system

Ammonia in pig farming housing

Factors influencing ammonia emissions from buildings

→Floor type

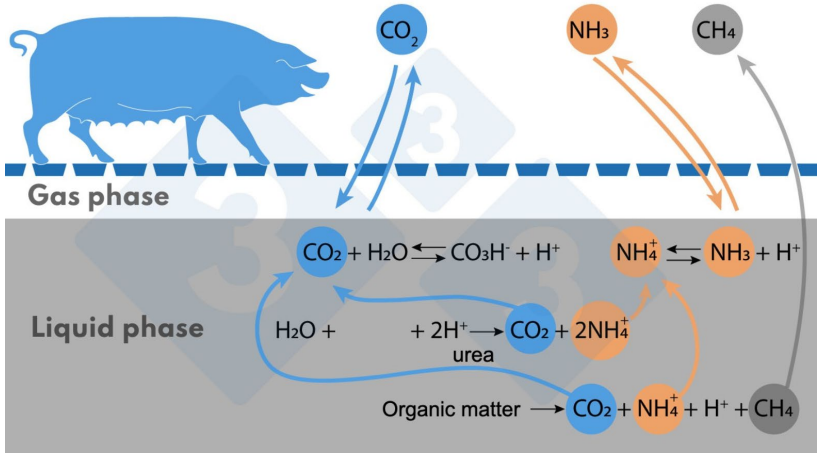
In pig production, the main housing conditions are based on slatted floor or bedded floor

- Slatted floor systems
- Bedded systems

→Ambient temperature and relative humidity

→Ventilation

→Air scrubbers



Source: Pig333.com

Seasonal and day/night variations

Greater ambient temperature in summertime increase NH_3 emissions.

Diurnal variations

→ NH_3 emissions are highly correlated with animal activity and especially with feeding and excretory behaviour (pigs excreted 1 h or 2 h after feeding, with consequent peaks of emissions)

→Diurnal variation of air movement over the floor due to active pigs and ventilation rate (consequence of increased heat production) contribute also to the diurnal NH3 emission

Good Practices pig farming housing

Reduce the surface area of the slatted area

→Maximise the transfer of excreted material to channels, preferably with a 50% covering

→Solid floor areas should have provisions such as a slight slope to allow urine to drain to the channels

→Channels should be emptied frequently by the use of scrapers, a vacuum system or by flushing with water, untreated liquid manure (under 5% dry matter) or separated slurry.

PigT pig toilet: *a special plastic floor separates faeces and urine immediately after excretion.*

Good Practices pig farming housing

Avoid ventilation directly above the surface of the slurry in the channels

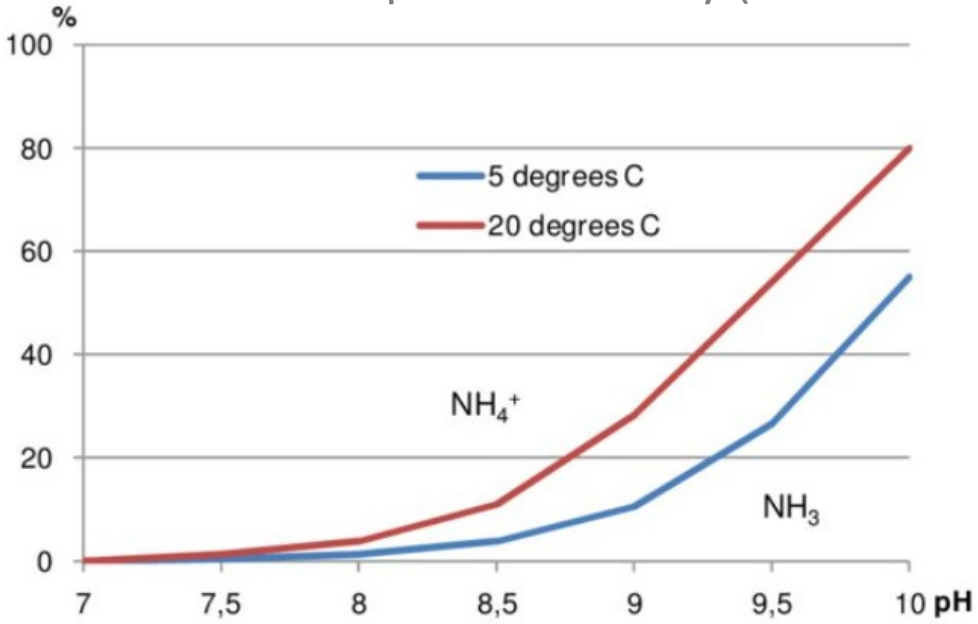
→Minimise the velocity of the air over the surface of the manure

→The gap between the slats and the manure surface should be sufficiently large to minimise air velocity (should be at least 30 cm)

Reduce the exposed surface of the slurry beneath the slats

→V-shaped gutters (maximum 60 cm wide, 20 cm deep) reduce the surface emitting areas. Gutters and walls should be smooth to prevent manure build up

→Reduce the pH of the slurry (acidification).



Effect of pH and slurry temperature on the potential for release of ammonia from manure (source: J. Jermakka et al, VTT Technical Research Centre of Finland)

Good Practices pig farming housing

Improve animal behaviour and design of pens

→Offer pigs functional areas for different activities

- → The aim is to keep the solid part of the floor as clean as possible
- → For example, pens with partially slatted floors should be designed so that pigs can distinguish separate areas for lying, eating, dunging and exercising

→Systems using bedding material such as straw should have sufficient bedding material to allow complete absorption of urine and be changed frequently

→Slatted and solid floor systems should use sloped floors, gutters, or scrapers (where possible)

- → Allows for rapid drainage so that urine and faeces are kept separate as ammonia emissions form when they mix

→Leakages of drinking systems should be avoided to prevent additional moistening of the bedding

- → Drinking systems need to be designed so that the drinkers are at the correct height for the size of animals and may need to be adjustable.
- → Nipple drinkers need to be adjusted for the desired flow rate for the water pressure present. Pipe work and drinkers need to be maintained to prevent leakage.
- → Actions necessary to prevent water wastage and prevent floors and bedding from getting wet

→Use of acid scrubbers or bio trickling filters to remove ammonia from the air

- → These devices are fitted to the outlets of mechanically ventilated pig housing

Improvements


Source: JM Lescot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Thank you!

Jean-Marie LESCOT

Agricultural expert

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