Indian Farming 70(07): 25–28; July 2020

Mitigation of odour
in swine production facilities

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Odour complaints have been identified as a major environmental challenge for the swine industry. Swine odour is generated due to anaerobic decomposition of manure, feed materials, and wastewater. Swine odours may become a nuisance that can interfere with the neighbour's quality of life and property values of nearby communities. Odours in swine farms, many of which not only are responsible for unpleasant odours but also affect the comfort, health, and production efficiency of animals as well as the comfort and health of workers.

Keywords: Canola oil, Odour mitigation, Olfactometer, Swine

ODOUR generation is one of the most relevant air quality issues in confined swine operations. Although odour exposure has been traditionally considered only a nuisance problem. It is now accepted that it can also impair health through direct irritation or psychopathologic mechanisms.

Odour from swine operations results from the anaerobic decomposition of swine manure. Compounds that pose concerns are ammonia, hydrogen sulfide, volatile fatty acids, p-cresol, indole, skatole, and diacetyl by either their relatively high concentration or low detection thresholds. Many technologies have been developed and attempted for odour management. Some examples are chemical and biological treatment of manure (including manure additives), dietary manipulation, liquid-solid separation, biofiltration, manure storage covers and dust suppression. However, few of these technologies are universally adopted by the swine producers. Air treatment systems for pig barns may represent a part of the solution to reduce odours and airborne contaminants. For this reason, in recent years, intensive research has been conducted to assess and control odours emitted from swine production facilities.

Sources of odour

Odour from animal housing, manure storage and treatment facilities and land application of manure is of great concern due to its negative impact on the local economy and quality of life. Feed and body odours are not regarded as offensive, but odour generated from anaerobic

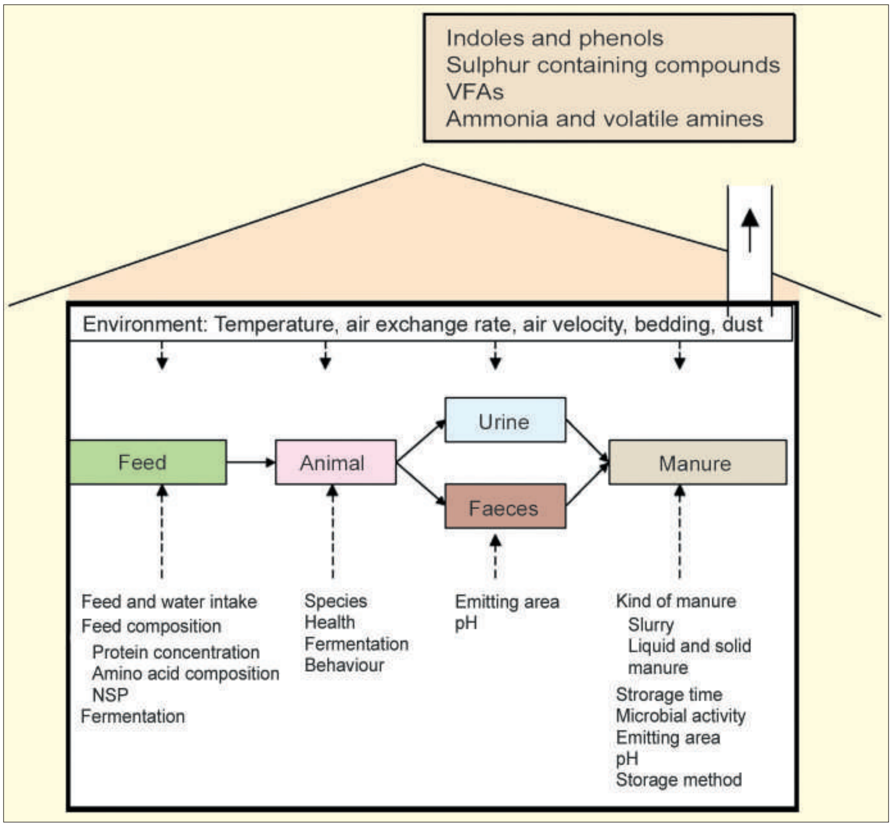

Fig. 1. Different sources of odour in Swine farm

decomposition of manure and during collection, handling, storage, and land application are considered offensive (Fig. 1). Odour emitted from manure is primarily due to an incomplete degradation of the organic matter contained in the manure such as protein, carbohydrates, and fats. Therefore, it is a challenge for researchers and technology providers to develop new technologies to minimize odour nuisance and air pollution.

Complex nature of swine odour and its constituents

An odour is a product of a complex interaction and mixing of individual odourous and non-odourous components that are produced during anaerobic degradation of organic matter in animal manure. Odours comprise hundreds of chemicals, including volatile organic compounds (VOC), ammonia (NH_3), and hydrogen sulfide (H_2S). Odourous compounds can be classified into five different chemical classes: i) Volatile fatty acids (VFAs), ii) Aromatic compounds (indoles and phenols), iii) Nitrogen containing compounds (ammonia and volatile amines), iv) Alcohols and v) Sulfur-containing compounds (hydrogen sulfide and mercaptans). Complex mixture of compounds, varies between animal types. As an example, approximately 330 different odourous compounds have been identified in swine production, whereas 110 compounds were found in dairy facilities. As a result, odour from manure is a complex mixture of gases.

Odour perception and evaluation

Odour samples are evaluated using an instrument called an 'olfactometer' with an odour panel. An olfactometer (Fig. 2) is a device used to measure the dilution ratio of an odour sample at the threshold of detection. A stream of odourous air is continuously diluted with a stream of odour free air in the device before being presented to a panel of people through a sniffing port. Currently research is underway for using commercially available electronic nose for odour evaluation of swine.

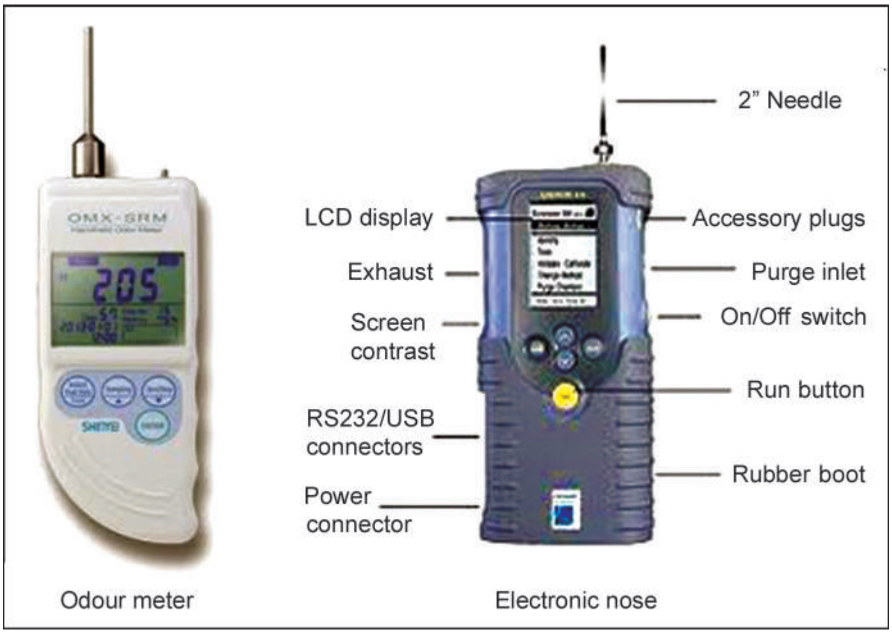

Fig. 2. Odour mitigation strategies

DIET MODIFICATION

Common diets usually supply more protein than required to satisfy the requirement for the most limiting nutrients. A reduced CP diet can be used without effects on animal performance by supplementing with synthetic amino acids (AA) to provide the limiting nutrients in the diet. Up to 40% reduction in swine N excretion has been reported by reducing dietary CP content and supplementing AA. Reduced N excretion due to reduced dietary CP content is mainly through the reduction in urinary N, and thus results in a lower ratio of urinary N to fecal N. Reduced dietary CP content is also associated with reduced manure pH. Reduction in urinary N and manure pH both favour reduction in NH_3 emissions.

Feed additives: It can be used to increase the digestibility and absorption of nutrients and to influence N excretion and pH of manure. Addition of fermentable carbohydrates can shift N excretion from urine (quickly degradable urea) to feces (slowly degradable microbial protein) and lower feces pH. Addition of acidifying salts can lower urinary pH and could reduce NH_3 emission by up to 40%. Benzoic acid has been evaluated as an emission-reducing additive for swine feed.

MANURE HANDLING AND TREATMENT

Solid-liquid separation: It means to reduce odour by mechanical or gravitational separation of solids from liquid manure. The N in urine is mainly in the form of urea and it is converted into volatile NH_3 after it is in contact with feces containing urease. If urine to feces contact is reduced, NH_3 formation will be reduced. Separated liquid will have lower biodegradable organic matter for anaerobic degradation, and separated solids will have much smaller volumes and air-manure contact surface, thus reducing odour emissions. Common separation units include gravity settling/sedimentation and mechanical screening, which require additional space and maintenance.

Storage additives: It has been proposed to add to the manure storage pit or sprayed on the manure to control odours. Common additives include biological additives (enzymatic or bacterial products); chemical additives (acid, disinfectants, or oxidizing agents); adsorbent and masking agents. Biological additives are usually odourant-specific. Slurry acidification can effectively reduce NH_3 emission, and improve S and N fertilizer value of treated slurry. It is approved as best available technology in Denmark.

Storage covers: It is used to reduce odours from liquid manure storage structures and lagoons. Covers are usually classified as permeable [e.g., straw, Geotextile® (a synthetic permeable cover), or a combination of both] which allow slow release of gases from storage, or impermeable (plastic, concrete, or wood), which do not allow manure emissions to be released to the atmosphere. Both permeable and impermeable floating covers decrease odour emissions by decreasing the solar radiation and direct wind velocity that transport odour constituents. Some permeable covers are thought to act as biofilters on top of stored liquid manure.

Anaerobic digestion: It is a widely applied technology for stabilization of organic waste and production of biogas and is one of the most effective end-of-pipe methods of reducing odour and air pollutants from swine manure. Anaerobic digestion has been shown to reduce VFAs by 79-97%, and thus reduces odour emissions. NH_3 volatilization was 22% less for anaerobically digested manure following surface application in comparison to untreated manure. Due to high cost, anaerobic digestion generally is not economically feasible for small operations. Co-digestion of manure with carbon-based substrates recently has renewed interest in enhancing the biogas production efficiency and economic viability of anaerobic digestion.

AIR TREATMENT

Biofiltration: It is an air-cleaning technology for the exhaust air from swine housing and sub-surface pits for manure storage (Fig. 3). The contaminated air passes through a filter media where microorganisms break down gaseous contaminants. Biofilters are made of moist and porous material with a large surface area in which odourants can be adsorbed and microorganisms can grow. If properly designed and maintained, biofilters can reduce up to 90% of emissions of odour, NH_3 and H_2S from ventilation fan exhausts. In general, recommended operating conditions for biofilters are: moisture 40-65%, temperature 25-50°C, and media porosity 40-60%.

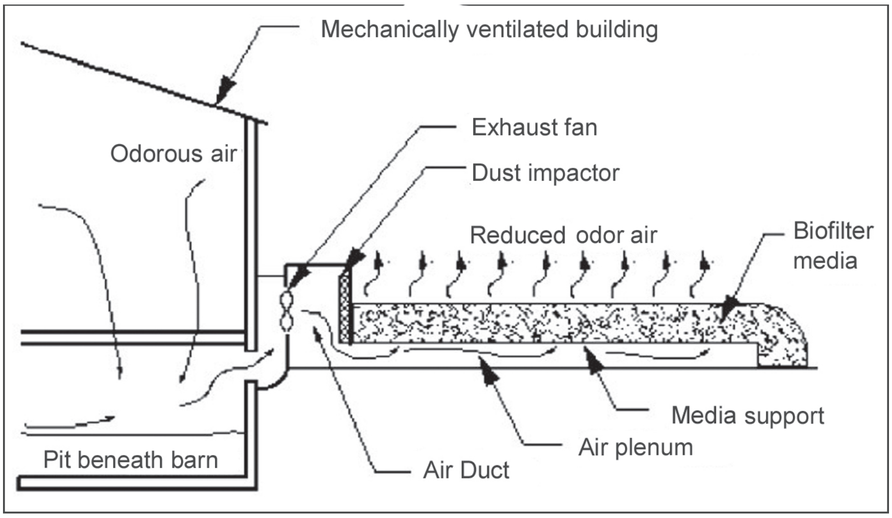

Fig. 3. Schematic representation of biofiltration process

Wet scrubbers: It has been developed for removing dust and air emissions from ventilation fan exhausts. A scrubber consists of a reactor with a filter made from an inert material (e.g., plastic) with large surface area. The filter is moistened with a sprayer or sprinkler system. Usually, portion of the used water is recycled and the rest is replaced with new water. Exhaust air is forced through the filter to ensure good contact between air and water. The simplest scrubber uses only water, while acid can be added into the recirculated water to improve reduction of NH_3 and make an acid scrubber. Research is ongoing to develop multi-stage scrubbers that are effective in reducing multipollutants with minimized water consumption and optimized microbiological processes.

Vegetative environmental buffers (VEBs): It can be established by planting trees around swine facilities. VEBs are thought to reduce dust and odour in two ways. First, VEBs work as a windbreak, enhancing vertical air mixing that results in more dilution, and slowing air movement that results in more deposition of dust. Second, VEBs reduce odour and dust as living bio-filters through interception and retention of dust, adsorption and break down of odour components. The surface cuticle which covers the epidermis of leaves of vascular plants has an affinity for Nitrogen based chemicals. VEBs have been shown to reduce downwind concentrations. Up to 50% reduction in NH_3 and dust; up to 85% reduction in H_2S and 6% to 66% reduction in odour. Greater species diversity and a combination of plant growth rates are recommended to make a robust and mature VEB system. Design of VEBs should consider air circulation near and through animal houses. Minimum distances of 23 m (75 ft) from a swine house are recommended for mechanical ventilation and 30 m (100 ft) for natural ventilation. Additional advantages of VEBs include visual screen (aesthetics value), snow fences, improved neighbour relations, and increased effectiveness over time.

Oil spraying/sprinkling: On floor and pen surfaces at regular intervals, it has been shown to reduce dust levels in swine buildings up to 46% and thus can potentially reduce odour. Up to 27% reduction in H_2S and a 30% reduction in NH_3 concentrations can be attained on using canola oil sprinkling (Fig. 4).

Photo-catalysis: It can be defined as a chemical reaction influenced or initiated by light. Titanium dioxide (TiO_2) has been widely used as photocatalyst. When a TiO_2- treated surface is irradiated with UV-light, an electron–hole pair is created and the hole generates highly reactive hydroxyl radicals, which can oxidize and break down many organic and inorganic air pollutants, including NH_3, NOx, H_2S, VOC, and CH_4. Research on the photocatalytic technology is ongoing to realize its potential to become a low-cost alternative to other mitigation technologies.

Managemental practices to reduce odour impact

Proper management and maintenance practices are essential to reduce impact of odour in swine production facilities.

Regular cleaning of facilities: Manure and feed particles can attach to floors, walls, equipment, and pigs, and represent significant odour sources. Regular and thorough cleaning of all surfaces that may have attached organic material can reduce these odour sources.

Ventilation: Minimum ventilation rate is crucial in maintaining a healthy environment for pigs and workers. The ventilation system should include properly sized fans and fresh air inlets. Minimum ventilation rates should be increased as the pigs gain weight (minimum 3.4 m^3/h for nursery pigs and 17-100 m^3/h for finishing pigs).

Floor design: Floor design can have a large impact on dust and odour levels in swine houses. Solid concrete floors with scrapers or small flush gutters have more wet, manure covered surfaces tend to emit more odourous compounds than slatted floors. Fully slatted or partially slatted floor allow liquids to drain through to a manure pit or gutter.

Drainage and manure removal systems: Good drainage of manure through a slatted floor can reduce odour sources by decreasing the area of waste influenced by slat design, width of openings, and material characteristics such as roughness and porosity. A partially slatted floor with reduced slurry pit area is known to have lower NH_3 emission than a fully slatted floor.

Frequent manure removal: How often and well manure is removed from swine facilities greatly influences the amount of odour generated from these facilities. Frequency and cleaning ability of the flushing water both have a great impact.

Fig. 4. Sprinkling of canola oil

Manure storage: Reducing the manure surface area and minimizing air circulation at the manure surface can be used to reduce emissions. Altering the pit design to use sloped pit walls or manure gutters could reduce the manure surface area.

Odour separation distances: Odour decreases exponentially with distance. Properly siting new swine facilities and establishing a sufficient distance between these facilities and neighbours with consideration of prevailing winds can be effective ways to minimize odour nuisance. When planning a new facility in hilly areas, it is best to choose a site that is not up-slope from close neighbours to avoid down hill air drainage carrying odours to neighbours.

Conclusion

The practices and technologies discussed vary in cost and effectiveness. Diet modification strategies have shown to reduce NH_3 emissions effectively with low cost, and should be considered as best management practices. Permeable covers and biofilters seem to have great potential to be the most promising and cost effective technologies for manure storage facilities and swine houses. Care must be taken to select technologies that are compatible with the management capabilities of the operation to prevent potential failure due to mismanagement. When trying to control odour, one should consider the whole farm system. No single method will completely eliminate odours from swine facilities, so a combination of different practices and technologies is recommended. Livestock producers face increasing pressure from regulators and neighbouring communities to control odour and livestock producers must comply with increasingly stringent regulations on pollutant gas emissions as required by local, state, and federal regulatory agencies.

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Know *Krishi Unnati Yojana*

The *Krishi Unnati Yojana,* a central sector scheme, is envisaged as umbrella programme for focusing on food security, by merging schemes on Soil-health Card, Integrated Scheme on Agricultural Co-operation and Agricultural Marketing, National Mission on Agriculture Extension, Horticulture Development, Price Stabilization Fund, National Mission on Sustainable Agriculture and other programmes.