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New research drives understanding of livestock odour reduction

An overview of solutions dedicated to the science of fighting livestock odour

Today's producers understand that livestock odour is becoming a key source of conflict in rural communities and one which represents a serious challenge to the survival of their operations. This has driven demand for efficient, cost-effective solutions which can not only reduce odour from livestock operations, but help producers and developers make decisions to avoid conflict over odour in the first place.

As a result, the science of reducing and measuring odour has grown in recent years, with new tools identified and tested for their effectiveness. "The search for better odour control is an ongoing process," says Ike Edeogu, odour control specialist with Alberta Agriculture and Rural Development (ARD) and a member of the Odour Control Team, a group of scientists from ARD and the University of Alberta.

"Research is helping us learn more and more about the efficiency and cost-effectiveness of odour solutions, causing us to take a fresh look at them and, in some cases, turning what we thought we knew about them on its head. What we have learned will hopefully help producers make better odour management decisions on their operations."

Key to that objective is developing the ability to measure odour with confidence. Science has made great gains in increasing the confidence in odour measurement and continues to do so. "Measuring odour objectively is a challenge because odour measurement is fundamentally subjective. However, the ability to measure accurately and consistently would help determine what odour-reducing technologies and management practices have the greatest potential to be effectively applied by the livestock industry." ✦

Alberta

Value of odour reduction tools assessed

Study tackles the cost-effectiveness of a number of popular livestock odour reduction solutions

A demand for tools which can reduce odour from livestock operations has driven the identification of several new solutions in recent years. But like anything new and relatively untested, these new developments have also prompted several questions. What are the costs versus the benefits? What technical factors help producers achieve optimal results from the technology or practice?

The bottom line, says Ike Edeogu, a leading researcher in the field of livestock odour, is that not every solution works for every producer in every circumstance. This point is illustrated by the results of a research project conducted by a network of odour researchers throughout the province, including staff from the AgTech Centre in Lethbridge, Alberta. The study was sponsored by the Alberta Livestock Industry Development Fund (ALIDF), Alberta Agricultural Research Institute (AARI) and Alberta Agriculture and Rural Development (ARD).

"Cost-effectiveness is ultimately the factor of most concern to producers," he says. "So it's important to carefully consider the various factors involved before adopting new odour reduction tools."

Biofiltration

Biofiltration works on the principle that odourous air can be filtered by passing it through a volume of material, or media, populated by microbial cultures that use pollutant gases in the air as food nutrients. The key to effective biofiltration is selecting biofilter media with adequate porosity, large surface areas and good moisture retention.

Wood chip and bark mulch media were tested in pig barns under a variety of water application methods, water rates and air distribution systems. The results suggested that biofilters are effective in reducing odour, particularly when using wood chips as media. However, maintaining the moist conditions necessary for effective filtration can be challenging, labour-intensive and costly.

"Although biofiltration is often touted as a quick and easy solution for odour mitigation, we found that the results do not justify the costs," says Edeogu. "Our results suggest that large expenses may be incurred and significant time spent creating and sustaining conditions favourable to the biofiltration process."

Oil sprinkling in barns

Past research suggests that sprinkling oil can reduce dust levels in pig barns by up to 95 percent. Its potential as an odour reducing tool has been driven by the possibility of a correlation between dust and odour levels.

The odour control team project did not confirm this correlation, however. Although refined, bleached and deodorized (RBD) oils emitted more pleasant, low intensity odours, and essential oils significantly improved the character of odourous air, there was little in the results to conclude that oil application reduces livestock odour.

"This confirms the outcome of some research and contradicts others," says Edeogu. "This is important information because, from a cost-efficiency perspective, RBD and essential oils can be quite costly, not to mention the set-up costs of installing spray systems. In addition, matters pertaining to the cleanup of oil deposits, the potential health risks to animals or humans from inhalation of aerosols from the oils, or risks of injury to animals from slippery floors, remain unresolved."

Diet modification

Primarily, the source of pig odour can be traced back to the incomplete digestion of dietary proteins and carbohydrates in the pig gut. Odourous compounds such as sulphides, volatile fatty acids and phenols are then produced following the partial anaerobic decomposition of undigested substrates present in the faeces. Reducing nutrient levels in pig diets may indirectly reduce odour emissions if the pig is able to utilize most of the nutrients in the diet rather than pass them out in the faeces. The downside to reducing nutrient levels in pig diets is that feed supplements will have to be added in order to sustain the animal's nutritional needs.

Nonstarch polysaccharides (NSPs) have been said to affect manure emissions by enhancing digestion processes, in turn reducing the need for protein-reduced diets. NSPs are not digested in the pig's small intestine but are instead passed to the hindgut, a change in process that has been reported to impact the production of odour-inducing substrates.

Experimental trials were conducted on eight pens of pigs using a range of protein levels and NSP supplements in feed. The results showed no significant effects on odour concentration or in the hedonic tone of emissions from manure. Hedonic tone is a measure of an odour's pleasantness or unpleasantness.

"Contrary to other studies, these results did not support the use of dietary protein reduction primarily to reduce emissions from stored swine manure," says Edeogu. "Although this project focused solely on emissions from manure, it is possible that diet manipulation could have beneficial effects on other aspects of pig production such as increasing nutrient retention in the animal, therefore reducing the amount of nutrients passed out in the faeces."

Composting vs. stockpiling

The primary difference between composted and stockpiled manure is oxygen. Oxygen is a key element in the composting process. When combined with a good source of carbon, nitrogen and moisture, it produces the high temperatures required for aerobic microbial activity. Aerobic microbial activity can only occur in the presence of oxygen. These microbes digest and process the various components of manure and are said to render it less offensive.

However, little research has been conducted to compare the odour emissions from composted manure to those of stockpiled manure. Over a 107-day period, the odour concentration and hedonic tone of a compost windrow and stockpile, both containing manure from a beef cattle feedlot, were compared.

Results indicated that the emission rates from the composted manure were significantly higher than the stockpiled manure during the active composting phase (days 1 to 78). By the end of the study however, there were no significant differences between the emission rates of the two treatments following the spreading of the stockpiled and composted manure on land. Hedonic tone ratings followed a similar pattern.

"The absence of significantly lower emission rates from the compost treatment was unexpected and may be attributed to low sensitivity of the measurement procedure," says Edeogu, who says high ventilation rates through the measuring device and the influence of background odours may have played significant roles in the end result. "Because of these compromising factors, it is unclear if composting beef cattle feedlot manure reduces odour emissions compared to stockpiling."

Compost additives

The potential of phosphogypsum (PG) as a compost additive to control odour is two-fold. First is its ability to react with gaseous emissions such as ammonia, thereby retaining nitrogen in the manure, and secondly, its ability to reduce the pH of manure, consequently inhibiting the production of gases such as ammonia. PG typically retains more ammonia in compost material, lowering the pH of the compost, changing its decomposition dynamics, and in turn it may reduce odour emissions.

In a commercial farm trial, six windrows of composted beef cattle feedlot manure were compared: three mixed with 10 percent PG and three without. The project's main objectives were to determine if feedlot manure could be effectively composted within pens housing animals and if PG would be effective in reducing odour and ammonia emissions during the composting process of feedlot manure.

The pH of the windrows amended with PG was lower and levels of ammonia-nitrogen were higher in the windrows mixed with PG compared to those without. "However, the results are inconclusive," Edeogu says. "The windrows were compacted as the animals trampled over them, resulting in reduced oxygen availability. This contributed to creating an environment not conducive for aerobic composting and, as a result, the product failed to compost. It was also high in moisture content, which typically inhibits the microbial activity necessary for composting by filling many voids in the windrow with moisture rather than air."

Odour is a very complex and difficult challenge for the industry, says Edeogu. "Even though the technologies evaluated did not result in a winner, it does provide producers with a basis for making decisions by knowing what doesn't work. The challenge is measuring a significant difference with the nose. That difference has to be about a 70 percent reduction in odour emissions before the nose can detect a difference.

"Much of the research has been based on odour concentration but our findings did note a difference in character or offensiveness," he says. "For example, a bakery may emit odour concentrations equivalent to a livestock operation but most people would prefer the bakery. Being able to measure a combination of concentration and offensiveness is a recommended approach for the future." ✦

Measuring odour with confidence key to scientific planning tool for siting livestock operations

Developing objective benchmarks for odour the main challenge in developing more accurate setback distances for confined feeding operations

Odour is fundamentally a matter of opinion. Although there may be a common consensus as to what constitutes a "good" or "bad" smell, the tolerance level for odours varies from individual to individual. A person who grew up in a rural community, for example, may have a higher tolerance for livestock derived odour than a lifelong urbanite who has just bought a rural acreage. On the other hand, there are cases in which just the opposite might be true, or the opinion could vary depending on the species of livestock.

Generally, the degree to which an odour is considered "strong" or "weak" is determined by its intensity, persistence and concentration. But what if science could find a way to measure odour by isolating the components which contribute to these factors and predict its dispersion from the source?

The result would likely be increased confidence when judging the potential odour impact of a livestock operation, says Ike Edeogu. "It would allow requirements for siting livestock operations to be applied based on objective scientific standards rather than subjective or experience based standards. Odour is treated as a nuisance under the regulations and being able to quantify odour would assist in the expansion and development of the livestock industry.

Measuring with confidence

Researchers in Canada generally follow European odour standards as a benchmark when determining the concentration of livestock odour. However, Edeogu says there is a need for home-grown standards to better reflect the rural situation in Canada and to help refine regulations on odour.

It was this need which drove a project by a province-wide network of odour researchers in Alberta, including the AgTech Centre in Lethbridge, to investigate ways to measure odour with confidence. The following were the significant findings:

Persistence a factor. "Because odour is typically presented as concentration, odour mitigation is usually considered to be a reduction in odour concentration," says Edeogu. "However, in this project the persistence of different livestock odours was found to differ. A more persistent odour will not dissipate as quickly in the atmosphere compared to a less persistent odour. This suggests that persistence levels could be used to scientifically determine the nuisance value of various types of livestock as stipulated in the regulations."

Odour intensity and concentration. A more scientifically accurate relationship between odour intensity and concentration was developed. "This means odour intensity measurements can be converted to units of odour concentration. This is significant because it helps us relate the impact of odour emissions from livestock operations to their downwind

Measuring odour intensity in the field

concentrations measured in the field away from the operation. It may also be used to scientifically define the concentrations associated with separation distances specified by the regulations."

Electronic nose shows potential. Odour concentrations measured with a commercial desktop electronic nose combined with a hydrogen sulphide sensor and an ammonia sensor showed a good relationship. A commercial handheld electronic nose, however, failed to show the same performance. "The alternative may be to design and fabricate a patentable electronic nose," says Edeogu.

Artificial livestock odour (ALO). This was developed as a reference odour to improve the accuracy of odour measurements compared to the accuracy based on the use of non-agricultural reference substances such as n-butanol. Although the ALO has yet to be extensively tested in a wide variety of applications, results suggested that n-butanol continues to be the most accurate reference compound for odour.

Higher measurement accuracy. Rigorous odour measurement protocols were developed to achieve higher measurement accuracy. These included maintaining odour sample quality in new and reused bags, maintaining reliable olfactometer operation, odour evaluation directly in the field, and measurement of representative odour concentrations from buildings and manure storage.

University of Alberta oflactometer

Normalizing odour measurement. Dr. G. Qu, previously with the Alberta Research Council, demonstrated that panellist responses from various labs across North America and Europe could be normalized, in other words, corrected for the variability between individuals. "This is significant because recruiting panellists that comply with the internationally recognized European standards is difficult," says Edeogu. "Normalization of odour measurements results in more accuracy when using less experienced panellists, enabling us to continue to measure odour confidently and objectively."

Measuring emission rates

Another aspect of the research focused on emission rates at the barn level, from manure storage facilities and other sources with large surface areas. These were the notable findings:

Sampling odour and ventilation rate

Monitoring ventilation rates. A reliable monitoring system for measuring ventilation rates from mechanically ventilated buildings was developed. "These measurements were used to determine odour emission rates from such buildings," says Edeogu. "It's a cost-effective pitot-tube system that can be easily installed for either ceiling or wall mounted exhaust fans."

Ventilation model developed. A ventilation model accounting for variables such as livestock species, number of animals, mass and outdoor and indoor carbon dioxide concentrations was developed to accurately predict daytime ventilation rates in naturally ventilated livestock housing.

Vented flux chamber technique. This was developed to improve the accuracy of odour emission rate calculations from earthen manure storages, feedlot surfaces and similar surface sources.

Emission rate database. A database of odour emission rates was created. It represents emission rates from dairy, poultry and pig operations.

Development of a scientific planning tool for siting livestock operations

The purpose of this project was to develop a planning tool for siting confined feeding operations (CFOs) using science-based information and methodologies. The three main steps included selecting a standard industrial dispersion model, gathering data from a CFO site in order to verify and calibrate the model, and developing a dispersion model as a planning tool to site CFOs.

The ISC Prime dispersion model was selected as a model suitable for the development of a scientific planning tool, while the research was conducted at a pig CFO using trained odour sniffers to record odour intensities in the field downwind from the CFO.

Key to the research was the ability to accurately predict odour levels downwind from livestock operations. In this respect, says Edeogu, the dispersion model was unsuitable because of the highly variable data affecting its accuracy. Although a simple to use, easy to modify planning tool for siting CFOs was developed, Edeogu says the limitations of dispersion models suggests that the tool should not be used to replace AOPA regulations for determining separation distances at this time.

Predicting odour dispersion

Air dispersion models are routinely used to estimate the position and value of a pollutant emitted into the atmosphere. The main finding of this project, which sought to test the reliability of a promising dispersion model for planning the siting of livestock operations, is that such models are generally unreliable for predicting the dispersion of livestock odours in the atmosphere and reveal highly variable results.

"Based on the odour emission rate data and measurements of odour intensity, the ISC dispersion model was unable to predict livestock odour concentrations downwind from a livestock operation that agreed with concentrations measured by trained human sniffers," says Edeogu. "The outcome leaves little doubt that based on the way odour is measured today, air dispersion models cannot be reliably used as planning tools to site new CFOs or expand existing CFOs." ✦

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