



# Fresh from the Farm

“Horrible doesn’t even begin to express it,” Joe Johnson says of the smell from the 21 hog barns that surround his home in Faison, North Carolina. For Johnson and his wife, Antoinette, the stench from the hog houses had turned their home into a foul-smelling trap where even closed windows, air conditioning, and incense couldn’t drown the odor. Their complaint, reported in the *Raleigh News & Observer* in July 1998, echoes those of other people around the United States who have reported symptoms ranging from nausea and headaches to mood changes in association with exposure to odors from animal waste.

The past decade has seen a transformation in U.S. livestock operations. The livestock industry, and particularly pork production, has consolidated into fewer, larger operations. Many hog farms have become what some people call “hog factories,” with rising animal densities in barns and larger anaerobic lagoons for waste. As a result, complaints about odor emissions and groundwater safety have increased [see *EHP* 106(5)A226–A227 (1998) and 103(12)1096–1100 (1995)].

The complaints and ensuing debate over how to address the problem of animal waste odors have spurred legislation in nearly a dozen states from Minnesota to North Carolina. Regulations vary from

state to state, but in late November 1998 the EPA moved closer toward federal involvement when it made a deal with pork producers that would allow farmers to avoid big penalties by participating in a national program of odor and water-quality inspection. Although regulatory action is one tack, hog and other animal farmers are also looking into technologies being developed by both private industry and universities to combat strong odors. Some of the most promising strategies include the low-tech, such as barley straw caps, and the more high-tech, such as waste biofilters.

### The Science of Smells

The science of odor as a health concern is still new. Merely identifying the hundreds of volatile organic compounds (VOCs) that cause livestock odors poses a big challenge. Susan Schiffman, a psychiatric researcher at Duke University Medical School in Durham, North Carolina, says that offensive livestock odors can potentially affect human health in several ways. First, odorant compounds can irritate the eye, nose, and throat, which can reduce respiratory volume. Second, the VOCs that cause odors can stimulate sensory nerves to cause neurochemical changes that might influence health, for instance by compromising the immune system.

Finally, unpleasant odors can trigger memories or attitudes linked to unpleasant odors, causing cognitive and emotional effects such as stress.

Schiffman reported on how odors can affect mood and stress, and thereby alter the immune system, in the Spring 1998 issue of the *Journal of Animal Science*. “Because unpleasant odors can produce impaired mood and stress,” she wrote, “they may influence health via biological mechanisms that include immune changes or hippocampal damage.”

Scientists who have investigated the health effects of the odors note that physical symptoms can be exacerbated by social divisions and perceptions. Kendall Thu, associate director of the Iowa Center for Agricultural Safety and Health in Iowa City, explains that “the physical properties of these emissions and their potential physiological and psychological effects are connected with the social conditions of rural areas. People [in rural areas exposed to animal odors] feel their sense of identity—their home, where they want their children to grow up—has been violated.” He adds, “The [World Health Organization] definition of health includes social health precisely because of this kind of situation.”

Besides the effects of odor on neighbors, ammonia emissions from open manure lagoons can return to surface water

in rainfall and foster harmful algal blooms. Researchers at North Carolina State University (NCSU) in Raleigh found that the ammonia content of rain in nearby Sampson County more than doubled between 1985 and 1997. The researchers traced this trend to growth in hog farm emissions.

Methods of measuring odors vary from state to state. In the 1970s, North Dakota instituted standards for acceptable odor levels in response to public concerns over hydrogen sulfide (H<sub>2</sub>S) emissions from oil- and gas-producing wells. The standards are based on the use of a scentometer, a device that looks like a little black box that measures odor levels. Although not as precise as mass spectroscopy, the scentometer provides a basic gauge of odor level in the field, and is inexpensive. Scentometer readings proceed stepwise in terms of odor strength from 2 (a noticeable odor) through 7 (an odor most people would find objectionable), 15 (most would declare it a nuisance), and 31 (extremely nauseating). Francis Schwindt, chief of the North Dakota Health Department's environmental health section, believes that the odor levels from livestock operations do not endanger public health. "The main concern is from a nuisance standpoint," he says, but he adds that odor problems can suggest problems with the VOCs that cause them, particularly H<sub>2</sub>S, ammonia, and methane-related compounds.

### On the Trail of the Scent

Late in 1997, EnviroPork, a private hog facility in Larimore, North Dakota, began



**The nose knows.** An apparatus called a scentometer enables researchers to measure the strength of animal waste odors.



**The last straw.** Covering animal waste lagoons with barley straw significantly reduces odors for as long as the waxy straw floats and no major cracks appear in the surface.

operations with 5,000 sows producing more than 100,000 piglets for sale each year. In early 1998, passersby on U.S. Highway 2, a major four-lane highway, complained of the facility's odor. The Health Department took scentometer readings, found they exceeded state standards, and directed EnviroPork to address odor concerns by a deadline of 3 August 1998. The Health Department recorded odor levels of 15 at the highway; in North Dakota any reading greater than 2 is a violation.

Bob Bergquist, EnviroPork's owner, says his facility tried several odor-reducing strategies, including feed additives to improve the pigs' digestive efficiency and enzymes to break down compounds in its waste lagoon. When these didn't solve the problem, the Health Department suggested EnviroPork contact the Energy and Environmental Research Center (EERC) at the University of North Dakota in Grand Forks.

The EERC reviewed EnviroPork's operation and suggested two main innovations: cover the waste lagoon with barley straw, and filter the exhaust air from the barns. The EERC had previously tested a straw cover on a wastewater lagoon at a sugar processing facility and found that barley straw substantially reduces odors at a relatively low cost and with minimal maintenance. According to EERC research engineer Tom Moe, the center learned of the covers from the Prairie Agricultural

Machinery Institute (PAMI) in Portage la Prairie, Manitoba. The cover reduces odor as long as the straw floats and no major breaks appear on the lagoon surface. Barley straw, applied to the lagoon using a specialized cannon that broadcasts up to 150 feet, provides the best unsupported cover because of its waxy coating and the stalks' tubular nature.

The EERC has evaluated other options, says Moe, but because EnviroPork was under the gun to implement a solution quickly, they recommended the barley straw, a relatively quick solution. "Put it on properly and you can basically forget about it," says Moe. If applied early in the spring, the covering may require only a few touch-up treatments over the summer. For EnviroPork, Moe estimates that the lagoon cover, including material, labor, and equipment rental, cost just over \$11,500 to install.

### Barnstorming Solutions

Experts generally agree that waste lagoons pose a greater odor hazard than livestock barns. "Well over half of [the odor] comes from the lagoon," says John Pickrell, an environmental toxicologist at Kansas State University in Manhattan. However, barns produce excessive dust emissions, an even greater health threat than odor, and thus may present a clearer opportunity for reducing health hazards. In recent years, researchers have revised their view of the symptoms experienced by some barn workers. The cough, chest tightness, and wheezing that were previously seen as an allergic reaction are now viewed as an inflammatory reaction to dust that could cause chronic lung disease, Pickrell says. "Some of these are pulmonary symptoms," Pickrell says; "some are pretty common with stress."

To reduce odor as well as trap particulate matter that may pose an inhalation hazard, the EERC developed a filter for the ventilation fans in the barns, says Dan Stepan, EERC research manager. Most agricultural biofilter designs use a horizontal orientation with the biomass bed spread out in pallets on the ground. This wouldn't work at EnviroPork because the filter would extend into the right-of-way of the nearby highway. So the EERC created its own design, using barley straw as a medium. They constructed filter walls measuring 80 feet long by 8 feet high by 2 feet thick near the exhaust of each set of ventilation fans, using a treated wood frame and chicken wire. Although research is still needed to gauge the filter's long-term effectiveness, tests showed that the biofilter walls removed dust particles, redirected airflow upward for better dispersion, and significantly lowered scentometer readings from above 15 down to 2 or below in almost all cases.

Bergquist confirms that both technologies appear to be working. Both H<sub>2</sub>S levels and scentometer readings have declined since the straw cap went on the lagoon, with scentometer readings near the lagoon plunging from 31 to "negligible." Readings outside the hog barn filter walls showed H<sub>2</sub>S concentrations of 2 parts per billion (ppb), down from almost 50 ppb inside the barn. "We're still doing follow-up tests with the EERC staff to find out why things work," says Bergquist. "I don't think there's one big magic wand," he adds. "It's a combination of management practices and technology that make it a success."

Schwindt says the Health Department is satisfied with these improvements, although additional biofilters may be needed for other ventilation fans on the farm. Ventilation fan filters and lagoon covers are now recommended by the American Society of Agricultural Engineers in its standard for controlling manure odors (last revised in November 1997).

In Minnesota, potential violations of the state's H<sub>2</sub>S emission standards led state health officials to respond to odor complaints. "Where there's odor, there may or may not be H<sub>2</sub>S, but when there's H<sub>2</sub>S, there will be odor," says Robert Criswell, a staff engineer with the state's Pollution Control Agency in St. Paul. Minnesota has a two-step standard: 30 ppb in half an hour may not be exceeded twice in a five-day period, and a yearly standard of 50 ppb may not be exceeded twice in a year. Measurements are taken at the property line of a facility. In response to a 1997 odor complaint, the agency recorded readings of 30–90 ppb H<sub>2</sub>S at the property line of one hog facility, which resulted in the first documented violation of the



North Carolina State Animal and Poultry Waste Management Center

**Gimme a break.** Windbreak walls divert air and odors away from neighbors and trap particulate matter from hog barns.

H<sub>2</sub>S standard. To comply, the company installed a felt-like synthetic polymer material atop its 7- to 9-acre lagoon (perhaps the largest in the state). The cover substantially reduced H<sub>2</sub>S emissions.

Minnesota farmers have also tried the barley straw lagoon covers and found them promising, especially on smaller lagoons. On one 2-acre lagoon cover, Criswell noticed, "The barley straw actually grew. You could see it had greened up." This could mean that the straw is more likely to float and stay intact. For larger lagoons, though, the area is harder to cover and the straw cap is more likely to shift and crack.



### More Hogs, More Odors, More Money

In North Carolina, the pork industry has grown faster and with less regulatory oversight than in the Midwest. The number of hogs in the state has nearly quadrupled since 1990 (from 2.5 million to 9.6 million), while the number of hog farms has shrunk by nearly half (from about 10,000 to 5,800). "Fewer people are raising more

hogs on much bigger farms," notes Tom Mather, a spokesman for the division of air quality in the state's Department of Environment and Natural Resources. "The mom-and-pop operations have largely gone by the wayside," he says.

Unlike North Dakota, North Carolina currently has no regulations specifically governing animal odors, but rather, has a general odor standard that is hard to enforce. "Complaints about odors have steadily increased as the industry has grown," says Mather. In 1997, the North Carolina General Assembly passed a bill directing NCSU to coordinate a study on odor controls. The bill also directed the state's Environmental Management Commission to draft regulations for odor

Energy & Environmental Research Center, University of North Dakota



**Just between phew and me.** Exhaust air from hog barns is forced through barley straw biofilters that absorb both odors and dust.

control in conjunction with the NCSU study. The NCSU study's initial findings were released in September 1998.

The NCSU study was led by Mike Williams, director of the university's Animal and Poultry Waste Management Center, which has supported research on waste management and related issues. The study describes several odor-control technologies the center has evaluated, makes recommendations for establishing odor standards, and includes an appendix of possible remedies for odor sources. "We have evaluated several technologies with promising results," says Williams, "but with the economic realities in the current market, they have met with mixed results from producers."

Although pork exports were up 24.8% as of November 1998 over numbers for the same period in 1997, according to the Foreign Agricultural Service, the prices for the exports are falling. Paradoxically, the U.S. hog industry is expanding despite the falling prices. A recent Foreign Agricultural Service report states, "Structural change in the U.S. hog industry has put many producers in the position of having to expand hog numbers to efficiently use recently constructed facilities. Hence, while in the past such low hog prices would have brought on a contraction in inventories, today more operations continue to expand, notably contract operations."

Among promising innovations evaluated by the NCSU study, Williams notes wind-break walls, similar to those installed at the EnviroPork facility but providing more of a physical barrier for diverting airflow, because in North Carolina's warmer climate, airflow rates from exhaust fans would have to be higher than those in North Dakota. Barley straw is also less readily available in North Carolina. The NCSU study therefore assesses lagoon covers as effective but costly.

Williams says separators are another promising technology. In one type, an upflow biofilter first separates solids from liquid waste and then flushes the liquid manure through two reactor towers about 15 feet tall. The towers contain layers of porous plastic. These layers provide a large surface area on which bacteria that have

been added to the tower break down odorous compounds and convert ammonia to nitrates. In a second-stage anaerobic polisher process, the nitrates are converted to nitrogen gas. "We're looking at numerous systems that use that [denitrification] approach," says Williams. The upflow biofilter system, manufactured by Ekokan, a company based in Cary, North Carolina, is expected to cost about \$50,000 for a facility of 800–1,200 hogs.

North Carolina's pork producers are leery of new technologies and their costs. "Over the past three years we've had 800 companies call and say, 'We can solve your problem,'" says Walter Cherry, executive director of the North Carolina Pork Council. Cherry directs them all to NCSU for evaluation. Moe agrees there are a lot of vendors with unsubstantiated claims. For Cherry, the downturn in pork exports shifts the frame for the debate to economics. He cites a two-year study funded by the Pork Council that found that only about 25% of the state's larger hog farms (2,500 or more animals) had odor problems or potential odor problems.

Don Webb, a former hog farmer and head of the Alliance for a Responsible Swine Industry, insists that the pork industry's influence in North Carolina has slowed odor-control efforts there. "The technologies to do something about odor are here now," Webb says, but the industry doesn't want to invest in them. Webb believes that the NCSU study team has been pressured to avoid costly measures, and to instead seek out technologies that convert the waste into usable commercial products, such as potting soil. To the dictum of nineteenth-century pork baron Gustavus Swift, who said, "We use everything but the squeal," Webb adds: "They want to make money off the squeal."



**Twin towers.** Waste separators in which odorous compounds are broken down by bacteria are another promising technology.

Still, there are signs that the winds of change are blowing through the hog industry. "There are technologies to take care of [odor]," says Schiffman, noting the lagoon covers, fan exhaust biofilters, good management, and better facility design. In November 1998, South Dakota voters approved a constitutional amendment allowing only family-run farms to operate in the state. (Family-run farms tend to be smaller facilities with lower concentrations of animals that produce lower levels of noxious odors.) And in North Carolina, new provisional rules regulating animal farm odors are expected to be in place by March 1, as directed by the state assembly. The current version of the rules sets minimum standards for all pork producers based on low-cost best-management practices. Beyond that, complaints about a facility can prompt the state to require a best-management plan for controlling odors. Meanwhile, the state's Environmental Management Commission is proceeding to develop permanent rules.

**David Taylor**

## Suggested Reading

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