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Hog farms pose risks of waste spills and runoff, but that's not all. The ammonia rising from lagoons could be even more hazardous.

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Every day for the past 20 years, a small research device in Sampson County has quietly monitored rainfall in the heart of the hog belt.

In 1985, the rain started to change.

First it showed a small spike in ammonia. Then the ammonia increased -- up 20 percent, up 40 percent. By 1996, the amount of ammonia falling in rain had more than doubled. For researchers such as Viney Aneja, it is no coincidence that this surge came as industrial hog farms multiplied across Eastern North Carolina, wafting up tons of ammonia each year from their barns and waste lagoons.

"There is no other possible source," said Aneja, a research professor in the Department of Marine, Earth and Atmospheric Sciences at N.C. State University. "Starting in about 1985, you see an increase in ammonia at that station. That correlates with the growth of the hog industry." For both pork allies and opponents, Aneja's research has enormous implications. For more than four years, factory hog farms have come under scrutiny for waste spills, noxious odors and contamination of streams and water wells. This environmental threat became clear in 1995 -- just days before the Fourth of July weekend -- when a hog waste lagoon in Onslow County broke open and dumped more than 22 million gallons of waste into the New River.

But if current estimates are correct, that spill might be a blip compared to the combined pollution that drifts upward daily from the state's 2,400 large hog farms, only to return to the ground by rain and wind. According to the N.C. Division of Air Quality, hog farms collectively discharge at least 186 tons of ammonia into the air every day -- about six times the nitrogen-rich waste that was dumped into the New River three years ago.

Such estimates alarm environmentalists, partly because ammonia is the most potent form of nitrogen that triggers algae blooms and fish kills in coastal waters. Moreover, the prevailing winds in Eastern North Carolina tend to blow emissions from the hog belt toward the Neuse and the Pamlico Sound.

"These are huge amounts of ammonia we are talking about," said Joe Rudek, a scientist with the Environmental Defense Fund in Raleigh. Hog farms now operate under "non-discharge permits," which prohibit them from dumping waste into streams and groundwater, he said. "Yet they are discharging to the environment all the time."

Along with other groups, the Environmental Defense Fund has urged state regulators to limit ammonia gases from large hog operations as part of a program to control the odors that often engulf nearby neighborhoods. But such measures are opposed by the state's big hog corporations,

which have financed a high-priced campaign to convince the public that they're not harming the environment.

"This whole area of atmospheric deposition of nitrogen is an area where there needs to be a lot of work," said Walter Cherry, executive director of the N.C. Pork Council. "I'm sure that animal operations, whether they be pigs or dairies or chickens or whatever, contribute some ammonia to the atmosphere. How much is still under debate."

The debate is closer to a conclusion. Over the past year, the state Division of Air Quality has drawn up estimates showing that hog farms constitute the largest source of airborne ammonia in North Carolina -- generating more than cattle, chickens and turkeys combined. Those estimates are now being confirmed by direct measurements of hog lagoons, part of a \$450,000 research program financed last year by the General Assembly, Aneja said.

State environmental officials say the potential for airborne pollution is another reason to phase out the lagoon-and-spray system. But they said they need more evidence that ammonia pollution is actually damaging water quality before they impose new regulations.

For all the recent attention, however, the concept that hog farms pollute the air is not new. For decades, university scientists, state regulators and industry leaders have known ammonia was billowing out of the barns, waste lagoons and spray fields of the livestock industry.

Until now, no one asked where it was coming down.

As far back as 30 years ago, scientists at N.C. State University and other institutions knew that when livestock manure is dumped into large pits such as the lagoons the pork industry now uses, as much as 50 percent of the nitrogen is "lost" as the waste decomposes.

Several studies over the years reported that some of this nitrogen is converted into ammonia, but scientists showed little interest in where that common pollutant ended up.

"There was not a lot of thought given at that time to ammonia volatilization, by anybody," said James C. Barker, an NCSU extension specialist who helped direct much of the research. Barker said everyone thought the amount of ammonia produced was so small that it would be dispersed harmlessly into the air.

In recent years, environmentalists have argued that the lagoons were designed to send as much nitrogen as possible skyward. Their opinion is supported by a 1993 report from Pennsylvania State University that advised livestock farmers to consider "atmospheric disposal" of excess manure -- using lagoons and sprinklers to send it into the air.

Barker said North Carolina farmers were never told to use their waste-management systems for that purpose.

"It was a consequence of the design," he said. "It wasn't a design factor."

Whatever the motivation, the relatively cheap lagoon systems were the key to the state's hog population tripling across Eastern North Carolina between 1984 and 1994. During that period, scores of lagoons replaced old tobacco and cotton fields in Sampson, Duplin and Bladen counties, and the state's hog population jumped to 7 million. It has since climbed to nearly 10 million.

By 1995, University of North Carolina marine ecologist Hans Paerl was reporting that airborne ammonia had risen 25 percent each year since 1991 in Morehead City, 90 miles downwind of the hog belt. Paerl also reported traces of urea -- pure urine -- in rain.

Paerl's findings were overshadowed by a string of hog waste spills in 1995, including the lagoon rupture in Onslow County. But they didn't go unnoticed by Aneja, the NCSU chemical engineer. Aneja, a native of New Delhi, India, didn't have much experience with factory hog farms, but he was a specialist in atmospheric emissions of sulfur and nitrogen compounds. Intrigued by Paerl's work, he began examining rainfall data from Sampson County and other stations across Eastern North Carolina.

"The data was pretty startling," Aneja recalls. By 1995, the ammonia in Sampson's rain had jumped 120 percent, while the ammonia levels outside the hog belt had not changed significantly.

Aware he was onto something, Aneja started organizing workshops and symposiums, teaming up with other scientists and, with help from the state, conducting direct measurements from a commercial hog farm lagoon. Although not yet published, that study confirms earlier estimates of hog lagoon emissions, he said, particularly during the summer, when a typical 5-acre lagoon pumps 15 to 30 tons of ammonia into the air every month.

What happens to this pollution? Although conditions vary based on season and location, Aneja says that about half of the ammonia rises as a gas and generally falls to forests, fields or open water within 50 miles, either in rain or fog. The rest is transformed into dry particles, which travel much farther -- up to 250 miles, he said.

Cars and power plants also generate pollutants -- mainly nitrogen oxide -- that fall into rivers. But such pollution is less worrisome than ammonia, researchers say, because ammonia is the food of choice for harmful aquatic plants.

"Nitrogen comes in different flavors to plants and algae," Paerl said. "Compared to nitrogen oxides, ammonia is relatively easier for plants to use."

Not all scientists agree that hog farms pollutants are fouling coastal waters. U.S. Department of Agriculture scientist Lowry Harper said his research indicates that hog farms emit a large amount of harmless nitrogen gas, while only 25 percent of the "lost nitrogen" is ammonia.

"Most of it goes into plant systems and forest systems a short distance away," Harper said. "Plants will absorb a tremendous amount of ammonia."

But Robin Dennis, a scientist with the U.S. Environmental Protection Agency, said his research shows that a sizeable amount of the ammonia is being carried to the coastal waters.

"I still think the hog farms in the Cape Fear basin are affecting the Albemarle-Pamlico," said Dennis, who specializes in airborne modeling at EPA's lab in Research Triangle Park. "I'm sure that stuff is getting over there."

State regulators say they still have a lot of questions: How much ammonia is absorbed by plants? What should be the state's targets for reducing ammonia? And how would the state measure the reduction?

"All those questions pop up and as far as I know, nobody knows the answer to them now," said Alan Klimek, the state's air quality chief. "It would be hard to design a control strategy until you fully understand the problem."

That perspective is shared by the pork industry, which defends the current technology even as it investigates alternative methods of disposing of swine waste.

Garth Boyd, director of land and nutrient management for Murphy Family Farms, said that researchers would need to trace molecules of nitrogen from lagoons to the Neuse for him to believe that a serious problem exists.

"We're not saying categorically that lagoons are great from an atmospheric standpoint," he said. "We're not saying categorically that they're bad . . . The facts aren't out."

The search for the facts has gained urgency with a looming deadline. In March 1999, the legislature's two-year moratorium on new farms expires, and unless lawmakers extend the ban, the state will allow farmers to expand their herds beyond the current population of nearly 10 million.

In April, Agriculture Commissioner Jim Graham released a report after the General Assembly directed his agency to devise a plan for phasing out lagoons. To the dismay of environmentalists and many legislators, the plan called for taxpayers -- rather than the large hog corporations -- to pay up to 90 percent of the cost of retrofitting farms statewide. Parts of the report also seemed to argue against the phase-out altogether, saying the systems provided "major pluses" in preventing water pollution "via overland flows to streams and rivers."

High-ranking state environmental officials disagree with the Agriculture Department's conclusions. Preston Howard, director of the N.C. Division of Water Quality, said the industry will eventually have to find an alternative to lagoons, which not only spew ammonia into the air but also are vulnerable to overflowing during rains.

"This is just another reason to move the industry away from the lagoon-sprayfield technology," Howard said.

Dewey Botts, director of the state Division of Soil and Water Conservation, said the problem of atmospheric deposition is more proof the state failed to anticipate the effects of so many lagoons. "The sheer size and numbers are something we didn't take into consideration," he said.

Botts said the state should develop criteria to evaluate every waste lagoon in the state and set up a priority system to phase them out. He favors shutting down some lagoons and covering others to attack the problem of odor and airborne ammonia.

"Until we can guarantee to the taxpaying public that we're not contaminating groundwater, not to mention surface water, not to mention odor, we are irresponsible to continue business as usual."